Volume 22 NOVEMBER, 1938 Number 11

BULLETIN
of the
American Association *of* Petroleum Geologists

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BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICE OF PUBLICATION, 608 WRIGHT BUILDING, TULSA, OKLAHOMA

THE BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS is published by the Association on the 15th of each month. Editorial and publication office, 608 Wright Building, Tulsa,Oklahoma. Post Office Box 979. Cable address, AAPGEOL.

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Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

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BULLETIN
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NOVEMBER, 1938

CARTERVILLE-SAREPTA AND SHONGALOO FIELDS, BOSSIER AND WEBSTER PARISHES, LOUISIANA[1]

G. D. THOMAS[2]
Shreveport, Louisiana

ABSTRACT

The Shongaloo and Carterville-Sarepta oil and gas fields are located in the north part of Bossier and Webster parishes, Louisiana, just south of the Arkansas-Louisiana state line. The Shongaloo field was discovered in March, 1921, and the Carterville-Sarepta gas was discovered in January, 1922, although oil was not discovered at Sarepta until 1924, and at Carterville until September, 1929.

The Shongaloo field is a dome-like structure, elongate east and west. The Carterville-Sarepta anticline lies immediately west of Shongaloo and consists of six small local closures along the main northwest-southeast axis of this anticline.

The Buckrange sand at 2,650 feet and two sands in the uppermost Tokio at 3,050 and 3,150 feet produce gas and oil at Carterville although only the Buckrange sand is productive at Shongaloo. The amount and extent of oil and gas is governed as much by variations in porosity and thickness of these three sands as by structure.

The disappointing recoveries of gas and oil per acre were due in a small degree to lack of great structural relief but in a large degree to lack of continuity and sufficient thickness of these three oil and gas horizons. Faulting can not be recognized from present data on these structures. The structures are generally believed to be the result of a local small amount of flowage of salt beds which underlie sediments of early Comanche or older age in north Louisiana and part of south Arkansas. Beds older than middle Glen Rose have not been tested in either field.

The results of the deep test now drilling at Shongaloo will have an important bearing on possible deeper drilling at Carterville-Sarepta.

INTRODUCTION

No paper has been written concerning the geology of Carterville-Sarepta or Shongaloo since October, 1923.[3,4] At that time the fields were just being developed and very little was known of the subsurface

[1] Read by title before the Association at New Orleans, March 18, 1938. Manuscript received, June 8, 1938.

[2] Geologist, Shell Petroleum Corporation.

[3] Gerald M. Ponton and John W. Whitehurst, "The Spring Hill-Sarepta Gas Field, Webster and Bossier Parishes, Louisiana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 7, No. 5 (1923), pp. 546-54.

[4] George Belchic and C. A. Breitung, "Gas Production from the Spring Hill-Sarepta Gas Field, Webster and Bossier Parishes, Louisiana," *ibid.*, pp. 555-57.

structure or actual conditions of accumulation. Therefore, it is believed worth while to set out in brief form the present knowledge of these two producing areas. Although the productive areas are almost continuous it is considered advisable to treat them separately.

ACKNOWLEDGMENTS

The writer is indebted to the Shell Petroleum Corporation for permission to publish this paper. He is grateful to R. R. Morse and members of the Shell Petroleum Corporation staff in Houston and Shreveport for suggestions and criticisms which aided greatly in the preparation of the paper. He is also grateful to C. L. Moody, W. C. Spooner, R. T. Hazzard, L. R. McFarland, and G. W. Schneider for information and criticism. Gerald M. Ponton and John W. Whitehurst,[5] George Belchic and C. A. Breitung[6] published valuable information which has been freely used.

Production data were obtained from major companies in Shreveport, which keep records of these fields.

It should be mentioned that current usage of the names Carterville-Sarepta and Shongaloo has caused them to replace the names Spring Hill and Sarepta, which were used in the earlier papers mentioned. The names Carterville-Sarepta and Shongaloo are now in use by the State Conservation Commission, by major oil companies in the district, and by various oil publications.

LOCATION

The Shongaloo field is in northwestern Louisiana near the north end of Webster Parish. It centers in Sec. 32, T. 23 N., R. 9 W. It is 24 miles north of Minden, the parish seat, and 35 miles northeast of Shreveport. The Haynesville oil field is 8 miles northeast, and the Carterville-Sarepta field centers 9 miles west of Shongaloo.

The Carterville-Sarepta oil and gas field is 9 miles west of the Shongaloo field in the north end of Bossier Parish and northwest corner of Webster Parish. It centers in Sec. 31, T. 23 N., R. 11 W. It is 20 miles northeast of Benton, the parish seat of Bossier Parish. The Cotton Valley field is 12 miles southeast and the Rodessa field is 24 miles west of Carterville-Sarepta.

A paved road runs north from Shreveport to Plain Dealing from which a graveled road leads northeast to Spring Hill and Shongaloo. Another graveled road leads east from Plain Dealing through Sarepta and Shongaloo to Haynesville. The fields may also be reached by

[5] *Op. cit.*

[6] *Op. cit.*

turning west from Haynesville on a graveled road. The nearest railroad is the Louisiana and Arkansas Railroad which runs north through the east tier of sections of Ts. 22 and 23 N., R. 11 W., through the towns of Sarepta and Spring Hill.

TOPOGRAPHY

The Shongaloo area has typical north Louisiana and south Arkansas low hills and shallow valleys with Dorcheat Bayou and its tributaries forming the drainage system. Dorcheat Bayou flows south across the western part of the gas-producing area. The Claiborne sand and shale beds at the surface tend to resist erosion. This results in the low hills in the area. The streams are approximately 180 feet above sea-level, while the highest hills have an elevation of 300 feet, or slightly less, above sea-level.

Bodcaw Bayou and its tributaries form the drainage system for the Carterville-Sarepta area. Bodcaw Bayou flows southeast across the southwest part of T. 23 N., R. 11 W., and forms the dividing line between Bossier Parish on the west and Webster Parish on the east. Most of the area west of the bayou is covered by terrace material and is relatively flat although there is low relief. On the east side of the bayou the normal outcrop is Claiborne as at Shongaloo and a maximum relief of approximately 120 feet is found. The streams are about 180 feet above sea-level and the highest hills are 275–300 feet above sea-level in the Carterville-Sarepta area east of Bodcaw Bayou. On the west side of the bayou only 70 feet or less of relief is found with the highest hills not more than 250 feet above sea-level.

SURFACE STRATIGRAPHY

The stream valleys and a large part of the area west of Bodcaw Bayou are covered by Pleistocene or younger sands and gravels. The hills are of Cook Mountain (middle Claiborne) age, with a few outliers of Cockfield (upper Claiborne) on the tops of the highest hills in the east part of the area. The Cook Mountain hills and valleys consist largely of sand and clay with a few fossiliferous beds cropping out. Weathering causes sand to wash over and mask many good outcrops which would otherwise be exposed. This is one reason why no more is known of the surface beds in the Carterville-Sarepta area. There are not sufficient outcrops to do dependable surface work on this structure.

SUBSURFACE STRATIGRAPHY

Figure 1 is a columnar section which applies to Carterville-Sarepta as well as Shongaloo. The Tertiary and Cretaceous beds have the

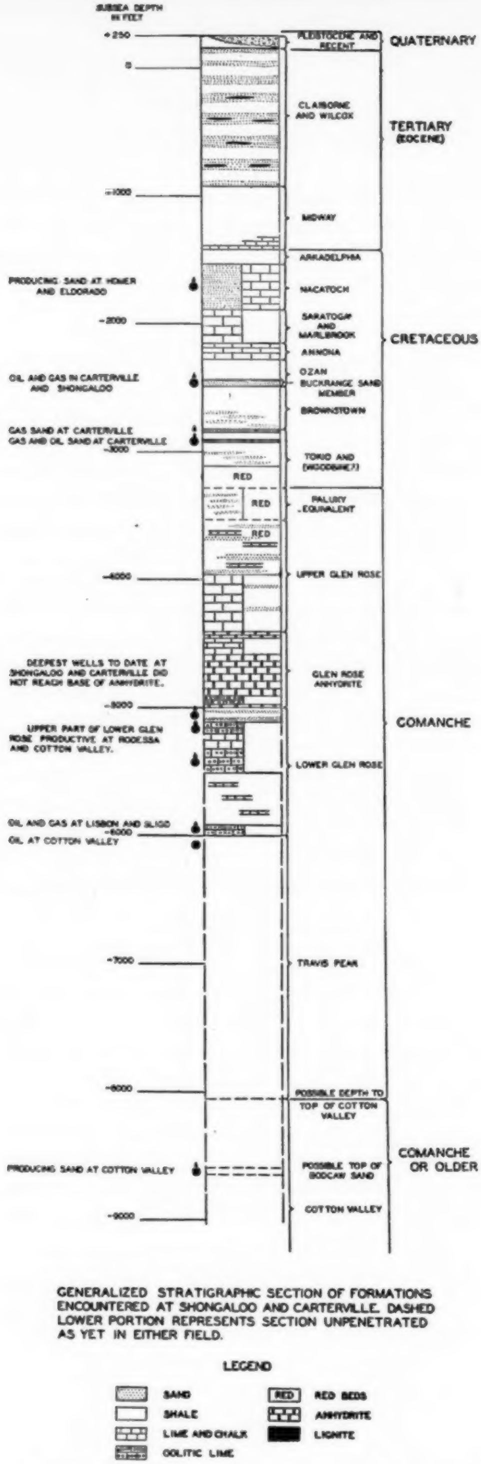


FIG. 1.—Generalized stratigraphic section of formations encountered at Shongaloo and Carterville-Sarepta.

same thickness for all practical purposes in both fields. However, due to the regional angular unconformity[7] between the Cretaceous and Comanche, the Glen Rose and older beds are found at shallower depths at Shongaloo than at Carterville-Sarepta. The interval from the top of the Comanche to the top of the middle Glen Rose anhydrite is only 780 feet in the Magnolia Petroleum Company's Sexton No. 1, a deep test now drilling, which is located in Sec. 32, T. 23 N., R. 9 W., as compared with the 1,130-foot interval for the same part of the section in Smitherman and McDonald's Oakley No. 1, which is located in Sec. 29, T. 23 N., R. 11 W., in the Carterville-Sarepta field. The beds older than uppermost Cotton Valley (Fig. 1) are not discussed in this report, because they have not yet been penetrated by wells in or near Shongaloo or in Carterville-Sarepta, and their presence, character, and thickness are therefore unknown.

TERTIARY AND YOUNGER[8]

The stream valleys are filled or partly filled with sand and gravel of Pleistocene or Recent age. Some of the wells penetrate a short section of this material before encountering the Claiborne of Tertiary age.

The Claiborne and Wilcox beds are approximately 1,150 feet in thickness at Shongaloo. The Claiborne consists of clays and sands with a few fossiliferous glauconitic green sand members and fossiliferous clay members. The Wilcox is composed predominantly of micaceous sand and shale beds with a few thin irregular lignite seams recorded in some well logs. The writer has been unable to determine definitely how much of the 1,150-foot section to assign to the Claiborne and to the Wilcox. The reason is that very few samples are now available on the older wells and cuttings on later wells are not ordinarily saved until after surface casing is set in the Wilcox.

The Midway is approximately 500 feet thick. It is composed mainly of dark gray or black micaceous shale. The basal part of the Midway becomes calcareous and contains glauconite grains. It contains as diagnostic fossils the micro-fossils *Hemicristellaria longiforma* and *Vaginulina robusta*, certain *Marginulina* species, as well as other calcareous foraminifera which are used by paleontologists in recognizing the presence of the lower Midway.

[7] W. C. Spooner, "The Oil and Gas Geology of the Gulf Coastal Plain in Arkansas," *Arkansas Geol. Survey Bull. 2* (1935), pp. 35 and 66.

[8] C. L. Moody, "Tertiary History of the Sabine Uplift," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 5 (May, 1931).

CRETACEOUS

Spooner[9] and Dane[10] give a fairly complete discussion of the Cretaceous formations. Only a brief description is included in this paper for that reason.

The Arkadelphia formation is approximately 120 feet thick in this locality. It consists of dark gray to black shale, calcareous in places. It is difficult to distinguish from the overlying Midway except on the basis of fossils contained. The micro-fossils *Globotruncana arca* and *Guembelina striata* are considered to be diagnostic of the Arkadelphia.

The Nacatoch formation is approximately 350 feet in thickness in this locality. It consists of sandy limestone, calcareous sandstone, sandy shale, and shale with small amounts of glauconite and pyrite present. Although this formation is commercially productive in a great many fields in a wide area in north Louisiana and south Arkansas, it is ordinarily non-porous in Shongaloo and Carterville, and although a few showings of oil have been reported[11] it is not an oil or gas producer in these areas. A study of the cross sections (Figs. 3 and 5) shows that the Nacatoch was not very well recorded by the drillers as the fields were developed. It is practically impossible to correlate the top of the Nacatoch or beds within it, from well to well, for that reason. The Arkadelphia and Nacatoch together are considered to be the equivalents of the Navarro of Texas.

The Saratoga chalk was not well logged by the drillers in these fields. It is grouped with the Marlbrook marl on the stratigraphic column (Fig. 1). In general the upper 50–100 feet is assigned to the Saratoga chalk, which consists of white chalk of upper Taylor age. The Marlbrook comprises the remaining 200 feet of the 270-foot interval assigned to the Saratoga and Marlbrook on the stratigraphic column. The Marlbrook is calcareous shale or marl for the most part.

The Annona chalk is the most easily recognized chalk member of the Cretaceous. It is given a thickness of 120 feet in the stratigraphic column. It is predominantly white to gray chalk with some thin shaly and sandy or gritty streaks. The base of this chalk has been used as a datum plane on the structure maps of Shongaloo and Carterville included with this paper (Figs. 2 and 4).

Micropaleontologists use *Anomalina taylorensis*, *Planulina taylorensis*, *Bolivina incrassata*, and other forms as index fossils of the Saratoga, Marlbrook, and Annona. These three formations with the

[9] W. C. Spooner, *op. cit.*, see also appendix.

[10] Carle H. Dane, "Upper Cretaceous Formations of Southwestern Arkansas," *Arkansas Geol. Survey Bull. 1* (1929).

[11] Gerald M. Ponton and John W. Whitehurst, *op. cit.*

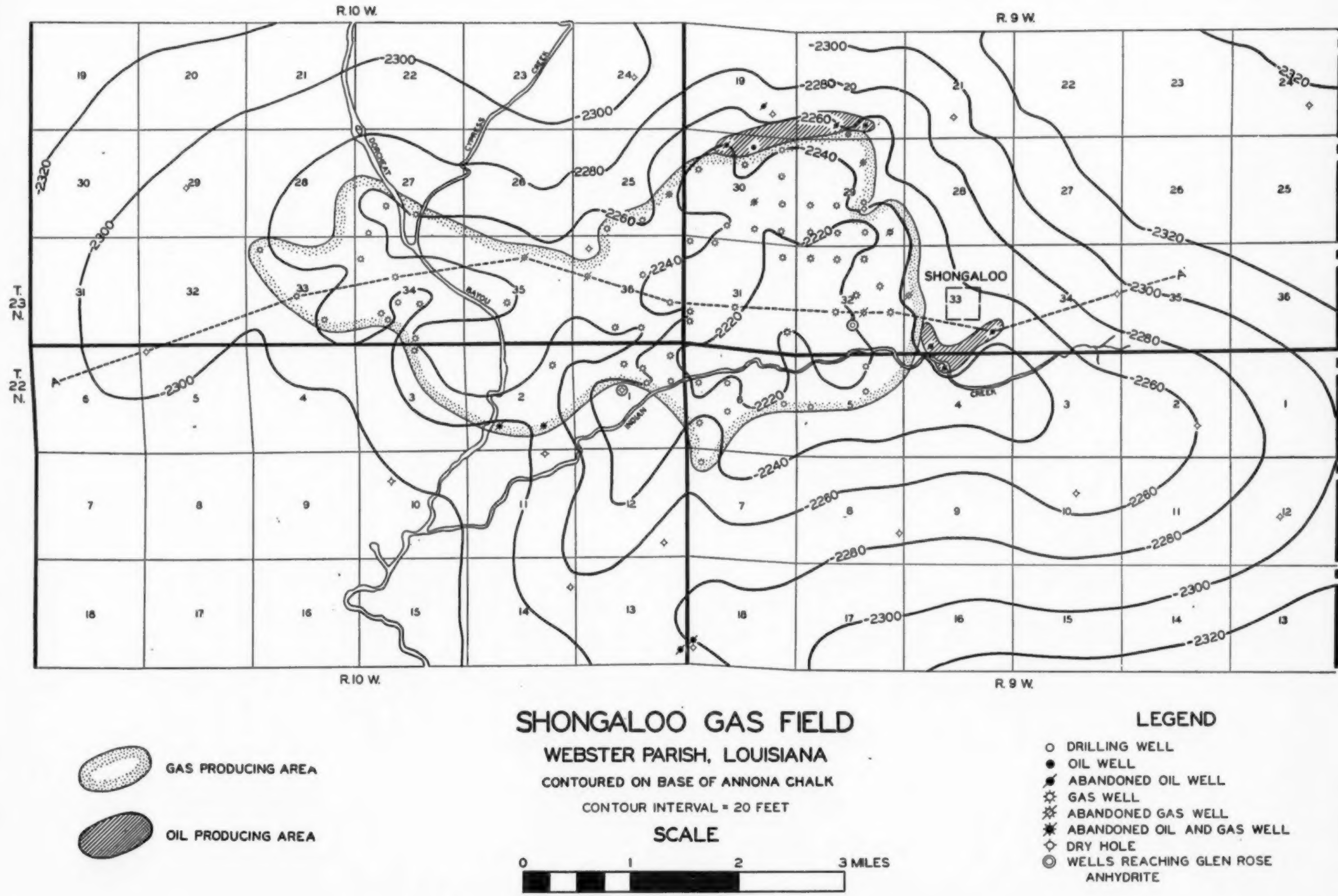


FIG. 2.—Structure map of Shongaloo gas field, contoured on base of Annona chalk.

underlying Ozan are all believed to be equivalent to the Taylor of Texas.

The Ozan has an approximate thickness of 200 feet in this general area. It consists of green and gray calcareous sandy shale with no prominent sand members, as a rule, except at the base, where the Buckrange sand, commonly 15–40 feet in thickness, is present. This is the producing sand at Shongaloo and the Sarepta oil area. It is medium-grained calcareous to non-calcareous sandstone, ordinarily with some glauconite and pyrite. Its thickness and porosity at Shongaloo are discussed under the heading "Producing Sands." Paleontologists use the micro-fossil *Kyphopxa christneri* as key fossil for the Ozan.

The Brownstown is assigned a thickness of 330 feet. In this locality it is composed of gray to dark gray calcareous shale with considerable mica and some thin sandy streaks, particularly in the lower part.

In this paper the Tokio formation is considered to be the basal Upper Cretaceous in this locality, although the question remains whether or not the lower red-bed part of the so-called "Tokio" is the remnant of the Eagle Ford or Woodbine of East Texas. The Tokio is approximately 470 feet thick in this locality. The upper 280 feet consist of gray to greenish gray calcareous shale and sandy shale. There are two prominent sand members in this upper part of the section, one at the top and one approximately 80 feet below the first. These two sand members are productive of oil and gas at Carterville. The lowermost 190 feet or less of the Upper Cretaceous is made up of red to brown and gray to greenish gray micaceous shale, sandy shale, and sand with some volcanic ash and bentonite. The Brownstown and Tokio together are the equivalents of the Austin of Texas although the basal red beds may be Eagle Ford or Woodbine in age. The microfossil *Vaginulina regina* is one of the marker fossils of the Brownstown, but the Tokio is recognized largely on the basis of its lithologic character because not many diagnostic fossils are found in beds of Tokio age.

COMANCHE

At Shongaloo it is probable that the first Comanche is upper Glen Rose in age with the Paluxy removed by truncation. It is the writer's opinion that a feather edge of Paluxy is present on the west in Carterville-Sarepta area. The interval from top of Comanche to top of middle Glen Rose anhydrite is approximately 800 feet at Shongaloo whereas at Carterville-Sarepta it is approximately 1,100 feet. The beds of the upper part of this interval are composed of red, gray, and green sandy and calcareous sandstones and calcareous siltstones. The

lower 400–500 feet of this interval is much more calcareous with interbedded black shale and light-colored fossiliferous limestone the predominant sediments.

Very few diagnostic fossils are found in this formation. Lithologic character is largely used as the basis for differentiating between the Paluxy and upper Glen Rose formations.

The Glen Rose anhydrite is approximately 500 feet in thickness at Shongaloo. It is composed largely of light and dark gray anhydrite and black shale with some oölitic and pseudo-oölitic limestone in the lower part. Boundaries of this formation are defined by lithologic character. The upper 10–50 feet has prominent anhydrite stringers and is usually called the first anhydrite stringer. The top of this zone is selected as the top of the Glen Rose anhydrite. The interval of approximately 120 feet between this stringer and the top of the "Massive anhydrite" is composed of fossiliferous limestone and dark calcareous shale. The "Massive anhydrite" is ordinarily 220 feet in thickness and is largely anhydrite and black shale. An interval of 80 or more feet below the "Massive anhydrite" is largely fossiliferous and oölitic limestone with some calcareous shale streaks. Below this is the basal anhydrite stringer of the Glen Rose anhydrite. It ranges from several feet to 30 feet in thickness. The base of the "Massive anhydrite" and the base of the anhydrite stringer are the best datum markers of the Comanche, and are commonly used in making Comanche structure maps in this district.

No well at Shongaloo or Carterville has yet penetrated below this anhydrite zone. The stratigraphic column shows with dashed lines the approximate thickness of the lower Glen Rose, Travis Peak, and the approximate depth to the top of the Cotton Valley formation and the top of the Bodcaw sand which produces gas and distillate in Cotton Valley, 12 miles south of Shongaloo.

The lower Glen Rose should be 1,000–1,100 feet thick at Shongaloo and Carterville and should be similar to the section penetrated at Cotton Valley. It consists, there, of sand, red shale, and dark shale in the upper 100 feet, fossiliferous and oölitic limestone, thin sands, and shale in the next 400 feet, and mainly black or very dark brown fossiliferous shale with a few oölitic limestone beds in the basal part for the next 500–600 feet.

The Travis Peak should be approximately 2,000 feet in thickness in this locality, judged by deep wells at Cotton Valley and on the north in Arkansas. This formation is largely sand and variegated shale with some mudstones. The topmost sand of the Travis Peak at Cotton Valley is variable in thickness and character and lenticular

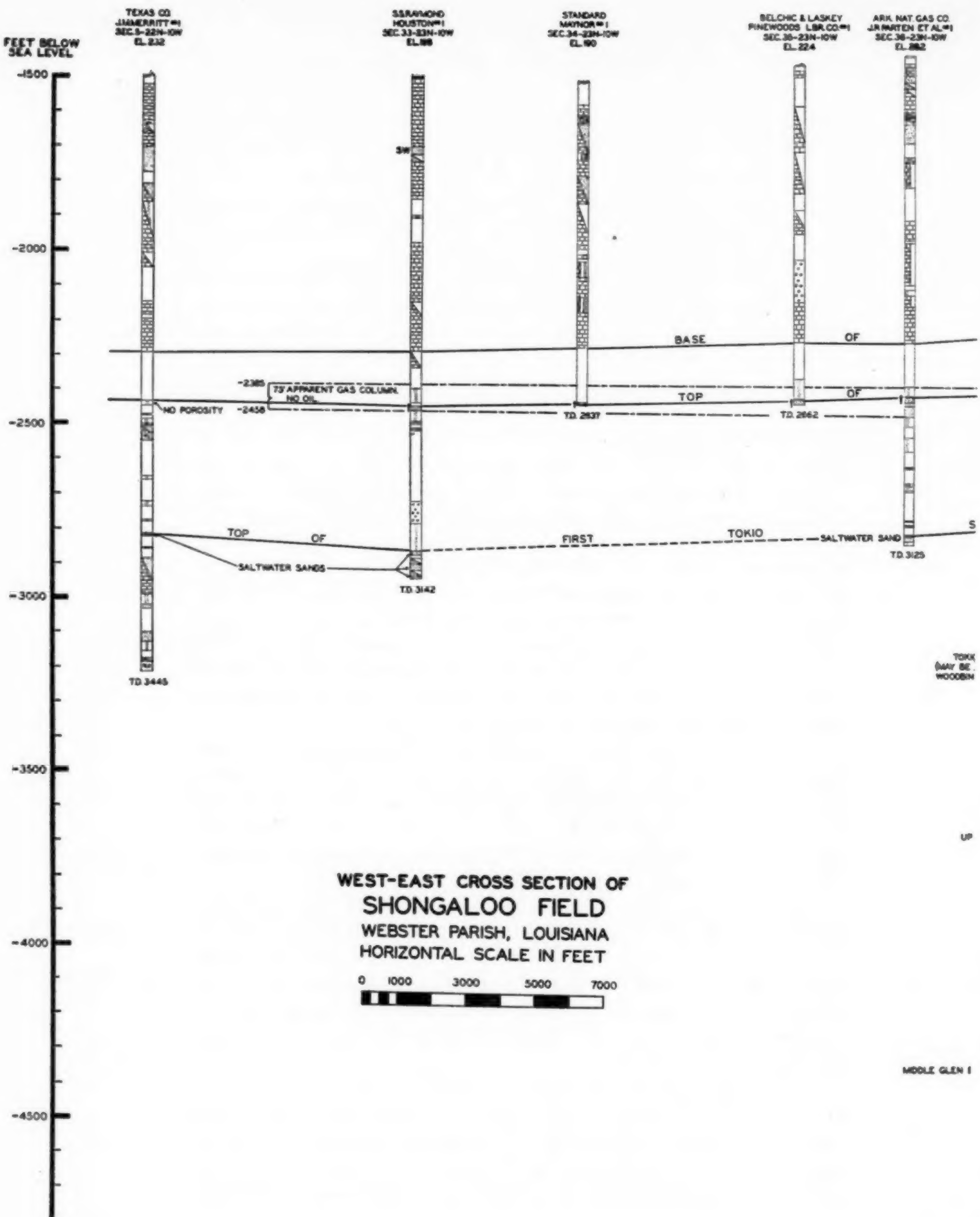
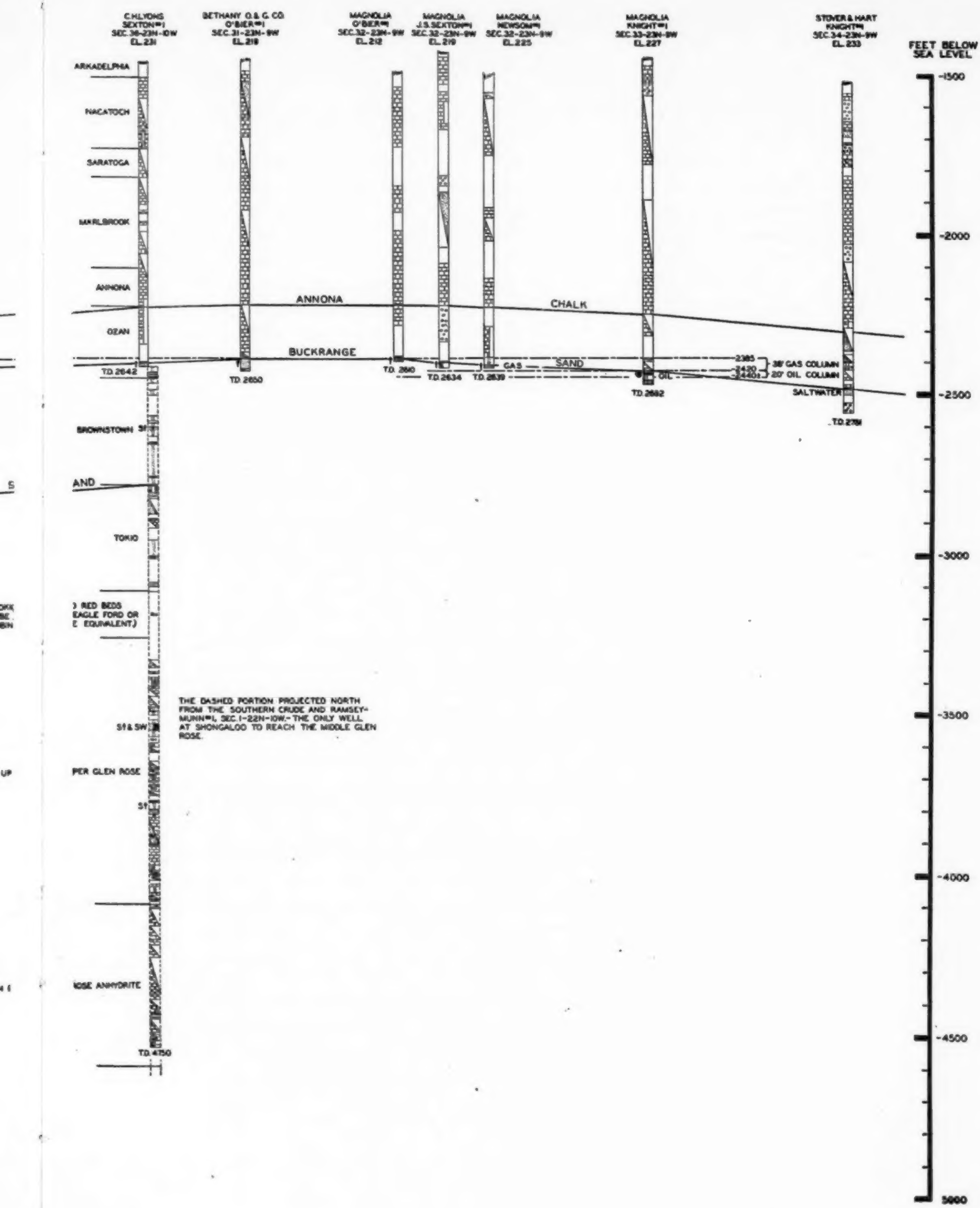


FIG. 3.—West-east cross section of Shongaloo field.



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EL. 225
MAGNOLIA
KNIGHT #1
SEC. 33-23N-9W
EL. 227
STOVER & HART
KNIGHT #1
SEC. 34-23N-9W
EL. 233
FEET BELOW
SEA LEVEL
ARKADELPHIA
NACATOCH
SARATOGA
MARLBROOK
ANNONA
OZAN
ANNONA
CHALK
BUCKRANGE
GAS
SAND
OIL
2385
2420
2440±
38' GAS COLUMN
20' OIL COLUMN
SALTWATER
T.D. 2642
T.D. 2650
T.D. 2610
T.D. 2634
T.D. 2639
T.D. 2682
T.D. 2781
BROWNSTOWN
AND
TOKIO
RED BEDS
EAGLE FORD OR
EQUIVALENT.)
THE DASHED PORTION PROJECTED NORTH
FROM THE SOUTHERN CRUDE AND RAMSEY-
MUNN #1, SEC. 1-22N-10W.- THE ONLY WELL
AT SHONGALOO TO REACH THE MIDDLE GLEN
ROSE.
ST & SW
PER GLEN ROSE
ST
OSE ANHYDRITE
T.D. 4750
-1500
-2000
-2500
-3000
-3500
-4000
-4500
5000

in distribution but has produced oil in a few wells where it is sufficiently porous.

Below the Travis Peak at Cotton Valley is found a series of dark fossiliferous calcareous shales with some hard sandstone members called the Cotton Valley formation which is Comanche or pre-Comanche in age. The most prominent sandstone member is 550 feet below the top of the Cotton Valley formation. It is approximately 40 feet thick at Cotton Valley and produces large quantities of gas and distillate. It is not within the scope of this report to discuss any older formations which may be present at Shongaloo and Carterville-Sarepta.

SHONGALOO

HISTORY

The discovery gas well of the Shongaloo field was the Louisiana Oil Refining Corporation's Gleason No. 1, in Sec. 13, T. 22 N., R. 10 W. This well blew in on March 3, 1921, producing approximately 10 million cubic feet of gas and a spray of oil. The derrick blew down and the well cratered, necessitating its abandonment. The gas and oil were encountered in the Buckrange sand from a depth of 2,791 feet. On October 5, 1921, the Portland Syndicate's Munn No. 1 in Sec. 1, T. 22 N., R. 10 W., was completed, making an estimated 44 million cubic feet of dry gas per day from the Buckrange sand; total depth was 2,662 feet. The Gleason discovery well was located by H. K. Shearer, geologist for the Louisiana Oil Refining Corporation, on surface and subsurface evidence of structure.

In October, 1923, 35 wells had been drilled and 13 gas wells had been completed. Most of the non-productive wells drilled were in the productive area, but blow-outs and junked holes caused their lack of success. Some of these 35 wells were in the Carterville-Sarepta field, however, as Ponton and Whitehurst[12] did not at that time differentiate between the Carterville-Sarepta and the Shongaloo fields. At present 117 wells have been drilled in this field. Of these, 84 were gas wells, 7 were oil wells, and 26 were dry holes. Although the Tokio sands were tested in several wells no oil in commercial quantities was found below the Buckrange sand. At present the Magnolia Petroleum Company is drilling a deep test in the field (Fig. 2) near the center of Sec. 32, T. 23 N., R. 9 W. This well has been drilled to a depth of 4,800 feet in the lower Glen Rose formation without important showings of gas or oil. The only other deep test of the structure is the Southern Crude and Ramsey-Munn's Wadley No. 1,

[12] *Op. cit.*

in Sec. 1, T. 22 N., R. 10 W. (Fig. 2), which was abandoned in basal Glen Rose anhydrite at a depth of 4,750 feet without important showings of gas or oil (Fig. 3).

Only one oil well is now producing oil from the Buckrange sand, and many gas wells have been abandoned. At present the Magnolia Petroleum Company, the Arkansas-Louisiana Gas Company, and the Northwest Louisiana Gas Company are running gas from the field. The Magnolia Pipe Line Company is taking the oil from the only oil well producing at present.

STRUCTURE

Surface.—Due to the nature of the Claiborne beds at the surface in the Shongaloo field, no satisfactory surface structure has been mapped, although some of the fossiliferous Claiborne beds give an indication that favorable local structure exists.

Subsurface.—The base of the Annona chalk was chosen as a contour horizon for this field, because of the poor information about any shallower marker due to poorly kept logs. The Buckrange sand and the base of the Annona chalk were used as double markers, but the base of the chalk was believed to be more reliable in most logs. This is because some sandy beds in the Ozan, above the Buckrange, were sometimes erroneously designated as the Buckrange sand. In other wells the Buckrange sand is absent or practically so. Figure 2 shows a structure-contour map of the field on the base of the Annona chalk. Some of the smaller irregularities shown are undoubtedly due to poor measurements and crooked holes. However, for most places the drillers' logs offer fairly good correlations.

The Shongaloo field structure on the base of the Annona chalk is an east-west elongate dome with approximately 50 feet of closure. The apex is in Secs. 31 and 32, T. 23 N., R. 9 W. It is separated from the Sarepta-Carterville field on the west by a saddle, and from the Cotton Valley structure on the south by a saddle. There is not enough drilling on the north and northeast to determine whether or not a pronounced syncline or a connection by saddle with Haynesville is present. There is no evidence of faulting of any major significance at Shongaloo. There may be minor faults but present data do not show them.

The bottom closing contour ($-2,260$ feet) encloses an area $3\frac{1}{2}$ miles north and south and 8 miles east and west.

Nothing is known of the structure of the Comanche beds. However, the Magnolia Petroleum Company has commenced a deep test, Sexton No. 1, in Sec. 32, T. 23 N., R. 9 W., after seismograph work

in the area. It is only 6 feet structurally higher on the base of the Annona chalk than the only other anhydrite test at Shongaloo, the Southern Crude and Ramsey-Munn's Wadley No. 1 in Sec. 1, T. 22 N., R. 10 W. However, it is 170 feet structurally higher than the Munn-Wadley No. 1 on the Glen Rose anhydrite. This difference may be partly due to regional northeastward convergence, but is probably due in part to local structure. It is a very interesting test because it is scheduled to be drilled to 8,500 feet, or to the Bodcaw sand of the Cotton Valley formation.

The origin of this structure is not clear but the generally accepted opinion is that it is probably caused by a small amount of flowage of the salt beds which are generally believed to underlie most of north Louisiana and part of south Arkansas.

PRODUCING SANDS

The only producing sand at Shongaloo is the Buckrange sand of basal Ozan age. Salt water was found in the few wells drilled into the 3,000-foot Tokio sands which are productive at Carterville. The Buckrange sand is found at an average depth of 2,600–2,650 feet in Shongaloo. It is variable in character and thickness. Some of the wells barely penetrated into it and others drilled through or partly through it. The pay zone ranges from very thin to 20 feet in thickness. Some well logs show sand below the oil and gas sand. This lower sand is believed to be generally non-porous because no showings of oil, gas, or water are recorded in it in most wells. Some wells at Haynesville, which is 8 miles to the east, penetrated 35 feet of oil sand in the Buckrange. There are not many data available as to porosity tests, but Belchic[13] used an average porosity of 20 per cent and a thickness of 15 feet. It is believed from a study of the available data that the porosity as well as the thickness is somewhat variable and that the amount and extent of production was governed as much by the variable sand conditions as by structure.

RESERVOIR CONDITIONS

Belchic[14] gives pressures on five of the original wells. These vary from 1,040 pounds to 1,215 pounds. The gas wells were originally capable of producing 15–60 million cubic feet of gas per day. The gas and oil columns appear to be somewhat erratic, probably because lenses of Buckrange sand produce farther down the south and west flanks than on the east and northeast flanks. On the northeast flank

[13] George Belchic and C. A. Breitung, *op. cit.*

[14] *Ibid.*

there appears to be a 35-foot gas column from −2,385 to −2,420 feet. Several wells on this flank found oil in the Buckrange with an apparent oil column from −2,420 to −2,440 feet. The oil column may amount to less than this, however, because of uncertainty as to exact well measurements. Below −2,440 feet the sand contains salt water.

On the west and southwest flanks the gas column appears to range from −2,385 to −2,458 feet, which is 73 feet. However, at this place the writer believes that downdip lenses of sand separated from the sand on the topmost part of the structure are the explanation of this apparently greater gas column. Two wells on the southwest flank in Sec. 2, T. 22 N., R. 10 W., found some oil with the gas from −2,440 to −2,458 feet. These wells had gas sand above the minus depths given for the oil. The discovery well for the area, the Louisiana Oil Refining Corporation's Gleason No. 1, in Sec. 13, T. 22 N., R. 10 W., sprayed some oil with the gas when it blew out. The top of the sand was found at −2,449 feet. It seems possible, therefore, that a narrow oil-producing rim in the Buckrange may almost surround the gas area. However, variable sand conditions make its development appear to be uneconomic at the present price of oil.

The reservoir pressure has decreased greatly—almost to the economic limit. A discussion of past and present production of gas and oil follows.

DEVELOPMENT AND PRODUCTION

The production curve (Fig. 6) and Table I show the production of oil to January 1, 1938. Table V shows gas production to date. It can be seen that the oil production has been very small. Only one oil well, the Ohio Oil Company's Haynes No. 1 in Section 30, is still

TABLE I

SHONGALOO FIELD. OIL PIPE-LINE RUNS

	Annual Production in Barrels	*Average per Month in Barrels*
1929	24,392	2,032
1930	35,683	2,972
1931	24,327	2,027
1932	12,973	1,081
1933	8,705	725
1934	7,363	613
1935	4,729	394
1936	4,477	373
1937*	4,523	377
Total to January 1, 1938	127,172	

* December, 1937, production estimated.
Future life of field = 8 years estimated (to 1945).
Total reserve = 22,000 barrels estimated.

pumping 10–12 barrels of oil per day. This is being run into the Haynesville field by the Magnolia Oil Company through its pipe line from Sarepta to Haynesville.

For the year 1937 only 162,136,000 cubic feet of gas was taken from the field, showing that the Buckrange sand is practically depleted of its gas.

At the present time only one well is drilling in the field. This is the Magnolia Oil Company's Sexton No. 1, in Sec. 32, T. 23 N., R. 9 W. This is to be a test of the Bodcaw sand of the Cotton Valley formation which is productive of gas and distillate at Cotton Valley 10 miles south, or to a depth of 8,500 feet if the Bodcaw sand is not encountered above this depth. If any horizons below the Buckrange are proved productive of gas or oil, there will undoubtedly be further development by the major companies and independents who hold practically all leases in a considerable area surrounding the test.

The field was developed on the basis of 40-acre spacing except where poor sand conditions made it uneconomic to drill on that basis. To date 84 gas wells, 7 oil wells, and 26 dry holes have been completed in the field and immediately around it. The standard rotary drilling rigs in common use at that time in this area were used at Shongaloo. Wooden derricks were used in most places. At the time this field was developed the present accurate measuring devices and improved coring devices were unknown, so that the writer is reasonably certain that some of the measurements were not exact. This accounts for some of the minor irregularities of the contours on the structure map.

TABLE II

Shongaloo Field. Pertinent Data

Age	17 years
Productive area	Gas 5,680 acres Oil 140 acres
Total production to January 1, 1938	Gas 70,991,134,000 cubic feet Oil 127,172 barrels
1937 production	Gas 162,136,000 cubic feet Oil 4,523 barrels
Number active wells	1 deep test
Number completed wells	Gas 84 Oil 7 Dry 26 Total 117
Producing formation	Buckrange sand at 2,600 feet
Average pay sand thickness	12 feet
Initial reservoir pressure	1,000–1,200 pounds
Production per acre to date	Gas 12,500,000 cubic feet Oil 908 barrels
Gravity of oil	28°–30° Bé.

Several of the earlier wells blew out and wasted considerable quantities of gas and lowered the reservoir pressure. Other wells were junked before the pay zone was reached. It is safe to say that if present drilling methods could have been used, a much better field would have resulted. Methods of setting casing and producing the wells in this field are not of interest because they were not unusual, and not according to what is considered present best practice in most places.

CARTERVILLE-SAREPTA

HISTORY

All of the Carterville-Sarepta field west of Bodcaw Bayou is generally classed as the Carterville part of the field and all of the field east of Bodcaw Bayou is classed as the Sarepta part of the field.

The discovery oil well for the area was drilled in Sarepta in July, 1924, and completed in the Buckrange sand. It was one of several tests drilled west of the Shongaloo gas field, after gas had been found in T. 23 N., R. 11 W., in January, 1922.

The gas at Carterville was discovered in December, 1926, as a result of westward drilling from the foregoing discoveries in the Sarepta part of the area.

The discovery oil well for the Carterville area was the Delaware-Louisiana Development Company's Bolinger No. 4, in Sec. 38 (32), T. 23 N., R. 11 W. It was drilled to a total depth of 4,005 feet in hard sand of Comanche age and plugged back to the Tokio sand at 3,170 feet. It was completed, flowing 50 barrels of oil per day, in September, 1929.

The first part of the history of Carterville-Sarepta is closely connected with that of the Shongaloo field. Because most of the gas wells dropped rapidly in volume and pressure and the oil wells were as a whole disappointing, the development of the field was not rapid until September, 1929, when oil was discovered in the second Tokio sand at 3,170 feet. This discovery caused the deepening of many wells previously producing gas from the first Tokio sand at 3,050–3,100 feet as well as the drilling of new wells.

At present there are 266 wells drilled in both areas, of which 86 were gas wells, 112 were oil wells and 68 were dry holes. The variable porosity and thickness of the Buckrange and Tokio sands accounts for the exceptionally large number of dry holes in the field.

The Shongaloo field deep test, the Magnolia Oil Company's Sexton No. 1, now drilling in Sec. 32, T. 23 N., R. 9 W., is important to the Carterville-Sarepta area as well. If this deep test has important show-

ings or oil in commercial quantities, it is probable that a deep test of the Carterville-Sarepta area will be drilled. Only one well has been drilled at Carterville, which reached the Glen Rose anhydrite. This is Smitherman and McDonald's Oakley No. 1, in Sec. 29, T. 23 N., R. 11 W. This well stopped in the basal oölitic limestone of the Glen Rose anhydrite just above the basal anhydrite stringer. Therefore it did not test any of the lower Glen Rose or older horizons, productive elsewhere in north Louisiana and south Arkansas.

No wells are drilling in the field at present. In December, 1937, a daily average of 330 barrels of oil was produced from the Carterville-Sarepta field, of which 209 barrels came from the Buckrange sand of Sarepta and 121 barrels from the Tokio oil sand of Carterville. No gas has been taken from Carterville since prior to 1934 because it is depleted. The Sarepta part of the field is also depleted of its gas and none has been taken since 1935.

STRUCTURE

Surface.—As at Shongaloo, the nature of the surface beds makes surface mapping practically impossible. The few Claiborne outcrops are not sufficient in number or of a character which can be used. In addition to this a large part of the area west of Bodcaw Bayou is covered by Pleistocene and younger sand and gravel, which do not permit structure mapping.

Subsurface.—As at Shongaloo, the base of the Annona chalk of Upper Cretaceous age was chosen as a contour horizon, and used for the accompanying map (Fig. 4). Because the general depths of the Buckrange and Tokio sands were known, the drillers failed in most instances to keep a good log of formations above the pay sands. A great many of the smaller irregularities in the contours are undoubtedly due to poor logging and inaccurate measurements. Most of the wells were drilled prior to the time that much accurate measuring of depth, crooked-hole surveying, and sampling were carried on, and also prior to the time of Schlumberger well surveying. However, the writer feels that the structure map (Fig. 4) shows a fairly accurate picture of structural conditions of the Carterville-Sarepta area.

The Upper Cretaceous Carterville-Sarepta structure appears to be a northwest-southeast extending anticline, on which six small local closures exist. The dip on the south side of the anticline appears to be steeper than that on the north side. The six local closures are here described.

The Carterville gas structure centers in Secs. 22 and 27, T. 23 N., R. 12 W., just southwest of the town of Carterville. There appears to

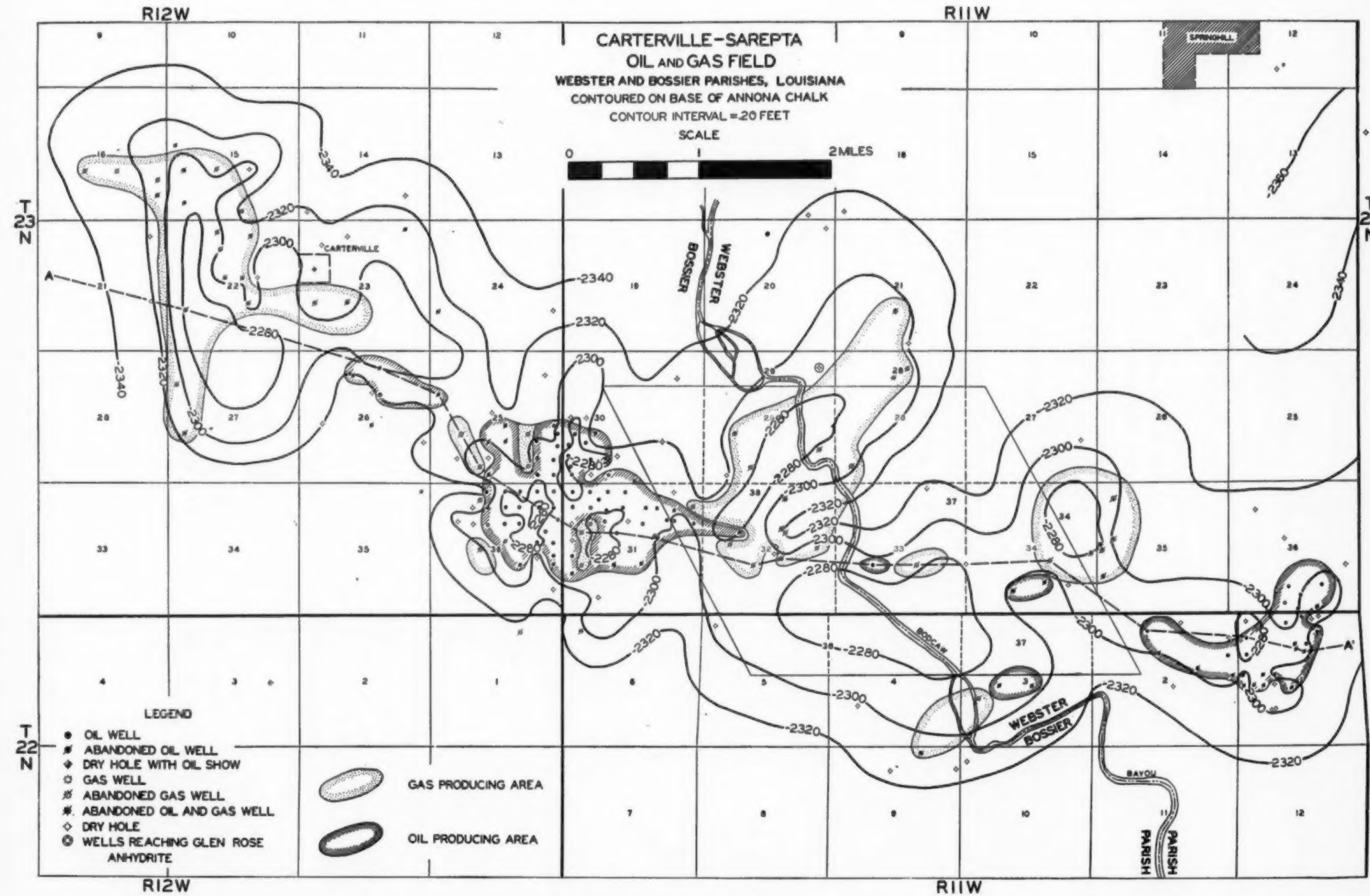


FIG. 4.—Structure map of Carterville-Sarepta field contoured on base of Annona chalk.

be 30–40 feet of local closure with the −2,300-foot contour on the base of the chalk the lowest closing contour. This local structure has a north-south minor axis crossing the main axis of the anticline almost at right angles. This local structure has produced only gas, from the Tokio gas sand at a depth of approximately 3,080 feet.

The Carterville oil structure centers in Secs. 25 and 36, T. 23 N., R. 12 W., and Secs. 30 and 31, T. 23 N., R. 11 W. The −2,290-foot contour is the lowest local closing contour and the topmost part of the local structure is at −2,260 feet in the northeast part of Sec. 36, T. 23 N., R. 12 W. This local structure produced gas and oil from the two prominent sand members of the topmost part of the Tokio. The gas sand is found at approximately 3,080 feet and the oil sand at approximately 3,160 feet below the surface. This local structure also appears to have a more or less north-south minor axis across the main anticlinal axis.

Immediately northeast of the Carterville oil structure is a local structure centering in Sec. 29, T. 23 N., R. 11 W. This local structure appears to lie slightly north of the main axis of the anticline and has a northeast-southwest axis. The lowest local closing contour is the −2,290 contour on the base of the chalk and approximately 20 feet of local closure exists. Only gas was produced from this local structure, from the Tokio gas sand at a depth of 3,040 feet below the surface and in a few wells from the Buckrange sand at approximately 2,680 feet below the surface. Both of these sands were variable in porosity and thickness on this local closure; therefore, drilling was not as close as well-spacing agreements allowed.

On the southeast, the next local closure is on the main axis of the anticline centering in the north part of Sec. 4, T. 22 N., R. 11 W. Small production of oil and gas was developed on the north and southeast flanks of this local closure. Due to variable and thin sands in the Buckrange and Tokio very few wells were drilled on this local closure and none was drilled on its highest part. There appears to be approximately 30 feet of local closure and the minor axis seems to be coincident with the main anticlinal axis. The −2,290 contour on the base of the chalk is the lowest closing contour. It is the writer's opinion that over this local structure the Tokio and Buckrange sands are thinner and less porous than the average for the entire field.

A small local closure lies immediately northeast of the one previously mentioned and centers in the NE. $\frac{1}{4}$ of Sec. 34, T. 23 N., R. 11 W. A few wells found gas on the west and south flanks in the thin variable Buckrange sand at 2,670 feet and a few others found gas in the Tokio gas sand at 3,070 feet, which was also thin and not

of economic value. This local closure lies north of the main anticlinal axis and has a north-south axis which is almost at right angles to the main anticlinal axis. There is apparently 20 feet or less of local closure. The −2,290 contour is the lowest closing contour.

The Sarepta oil area is on a local closure centering in the NW. $\frac{1}{4}$ of Sec. 1, T. 22 N., R. 11 W. This local closure lies on the main anticlinal axis and has a minor northeast-southwest axis. Not more than 20–30 feet of local closure exists here with the −2,290 contour the lowest closing contour. This area produces oil from the Buckrange sand.

The entire anticline from Sec. 16, T. 23 N., R. 12 W., to Sec. 1, T. 22 N., R. 11 W., is 10 miles long. The largest local structure, the west Carterville gas area, covers an area 2 miles north and south by $2\frac{1}{4}$ miles east and west. The Carterville oil area is $1\frac{3}{4}$ miles long east and west by $1\frac{1}{2}$ miles wide north and south. The Sarepta oil area is $1\frac{3}{4}$ miles long east and west by $\frac{3}{4}$ mile wide north and south.

No faulting is known at Carterville-Sarepta, although data available are of such poor quality that the possibility of faulting can not be ruled out entirely.

Nothing is known of the structure of the Comanche and older beds. Only one deep well, Smitherman and McDonald's Oakley No. 1, a 5,120-foot dry hole in Sec. 29, T. 23 N., R. 11 W., reached the Glen Rose anhydrite (Fig. 5).

As at Shongaloo, the origin of the structures at Carterville-Sarepta is uncertain, but the generally accepted opinion is that they are caused by a small amount of salt flowage of the salt beds of Comanche or pre-Comanche age which it is generally believed underlie most of north Louisiana and part of south Arkansas.

PRODUCING SANDS

There are three producing sands at Carterville-Sarepta. The Buckrange sand produces oil in the Sarepta oil area and some gas in a few scattered wells elsewhere in the Carterville-Sarepta field. The topmost sand member of the Tokio produces gas throughout Carterville-Sarepta where sufficiently porous and well developed. The second prominent sand member of the Tokio approximately 60 feet below the gas sand already mentioned, produces oil in the Carterville oil area. It is more erratic in character and thickness than either the Buckrange sand or the Tokio gas sand.

The Buckrange sand is found at an average depth of 2,600 feet in Carterville-Sarepta. It is variable in character and thickness. The pay zone is from almost zero to 20 feet in thickness with an average

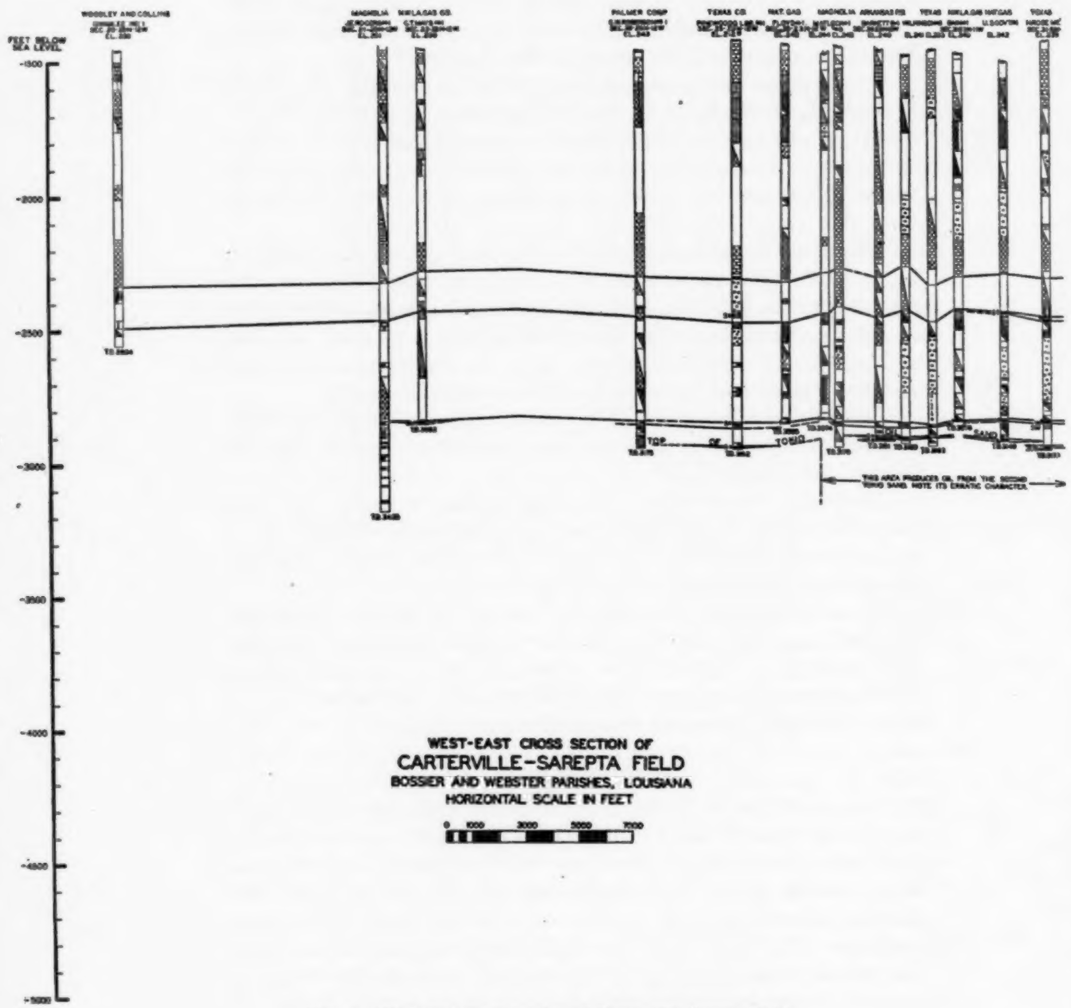
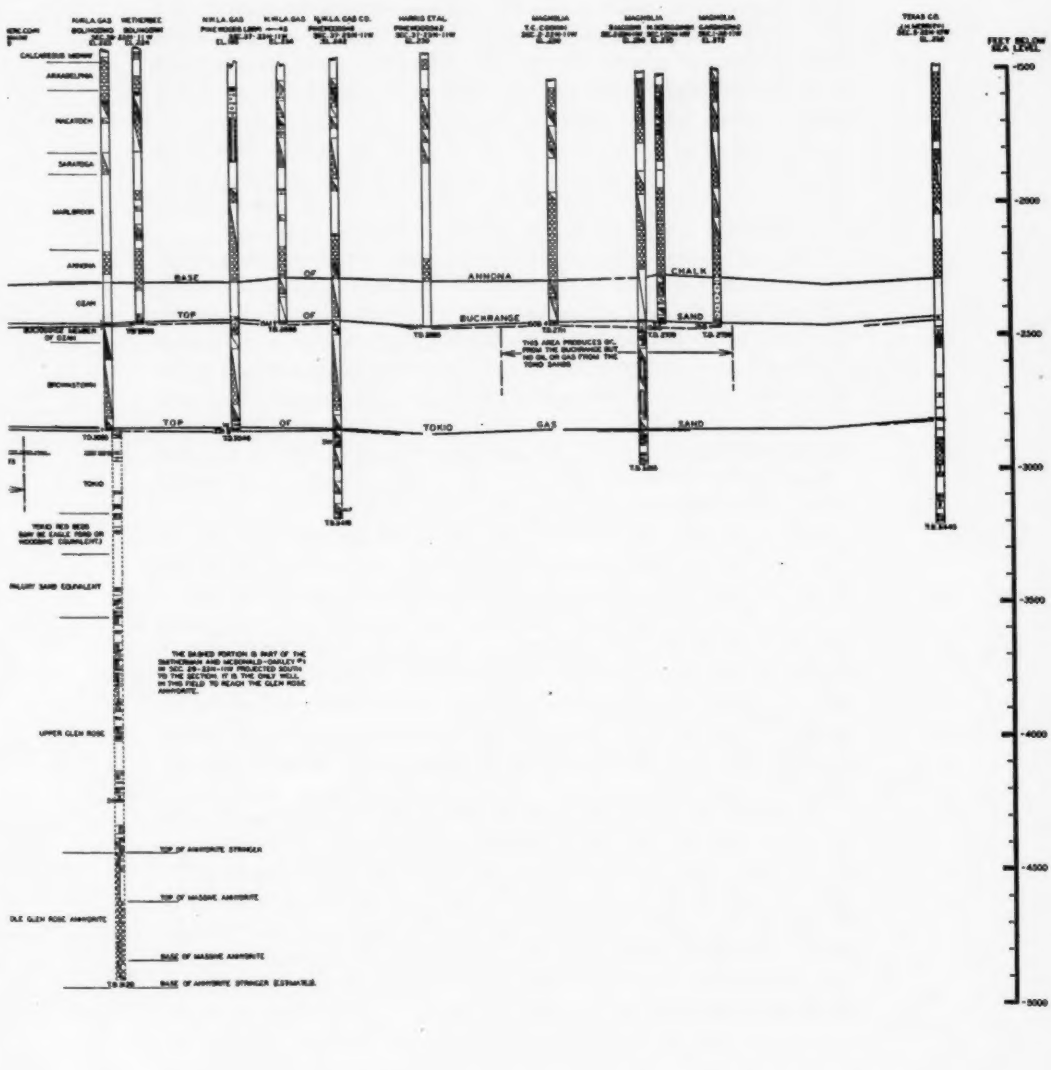


FIG. 5.—West-east cross section of Carterville-Sarepta field.


MAGNOLIA
TEXAS CO.
BASE OF ANNONA CHALK
TOP OF BUCKRANGE SAND
TOP OF TOKIO GAS SAND
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000

thickness of not more than 12 feet. It is a calcareous fine- to medium-grained sandstone which ordinarily contains considerable glauconite and small amounts of pyrite. The total Buckrange sand has a maximum thickness of 50 feet but the lower part either contains salt water or is non-porous. Its porosity is variable and no good data are available on actual porosity tests.

The amount and extent of oil in this sand are governed as much by erratic thickness and porosity as by position on structure. This is the oil-producing sand in the Sarepta part of the field where it has produced only 2,302 barrels per acre to January 1, 1938.

The first Tokio sand, or Tokio gas sand, occurs at an average depth of 3,050 feet. It is also variable in character and thickness. The pay zone ranges from almost zero to 20 feet but has an average thickness of 10 feet or less. This sand is shaly and in some places calcareous. It is fine-grained and contains some glauconite and white mica, with lignitic inclusions here and there. The amount and extent of gas production from this sand is governed as much by porosity and character as by structural position. This sand produces gas on structure where porous enough, but no oil production of commercial importance is known to have been obtained from it.

The Tokio oil sand occurs 60 feet below the gas sand discussed in the preceding paragraph at an average depth of 3,110 feet. It is very erratic in character and thickness, with best sand conditions developed in the Carterville oil area where it has produced only 1,992 barrels per acre to date. The pay zone ranges from almost zero to 15 feet in thickness with an average in the Carterville oil area of 7 feet. The pay section consists of sandy lignitic shale and very fine- to medium-grained gray sand which is non-calcareous. The cementing material may be volcanic ash. Some glauconite, brown mica, and pyrite are present.

The amount and extent of production of oil in the Carterville area from this sand are governed almost entirely by porosity instead of structure although favorable local structure also exists. Figure 5, the cross section of this field, shows the erratic nature of this sand. Although this part of the section was penetrated by many wells throughout Carterville-Sarepta, it was found to be so shaly and non-porous over the structure, except in the Carterville oil area, that it could not be classed as a possible pay zone elsewhere.

RESERVOIR CONDITIONS

The original reservoir pressure of the Buckrange sand was 1,000–1,200 pounds. The gas wells from this sand were not as large, on the

average, as those from the same sand at Shongaloo. Wells varying from a few million to 50 million cubic feet per day initial open-flow capacity are recorded. The oil wells in the Sarepta part of the area had initial productions varying from a few barrels to several hundred barrels per day, depending on thickness and porosity of the sand. The oil column at Sarepta is only a very few feet in thickness. It is impossible to determine accurately the water level and the approximate thickness of the oil and gas columns because very little structural relief actually exists and erratic sand lenses have a more important bearing on these levels than actual structural position.

The sand is depleted of its gas and an average of only 209 barrels of oil per day was produced in 1937 from the Sarepta oil area.

The Tokio gas sand had an original reservoir pressure varying from 1,000 to 1,250 pounds. The gas wells from this sand had 15–60 million cubic feet per day open-flow capacity. A few of the edge wells have produced a small amount of oil from this sand. Apparently any well, higher than −2,300 feet on the base of the Annona chalk (Fig. 4), which found favorable sand conditions in this horizon produced gas. Therefore a gas column of 40 feet with a very thin oil column between the gas column and the water level may be assumed. In this sand also the character and thickness of the sand had more bearing on the extent and amount of production than the local structural condition. The sand is depleted of its gas. None has been taken from Carterville since prior to 1934 and none from Sarepta since 1935.

The Tokio oil sand which is approximately 60 feet below the Tokio gas sand previously discussed is the deepest commercially producing sand yet found in Carterville-Sarepta. The original reservoir pressure was approximately 1,250 pounds, or slightly less. The initial daily production of the wells in this sand in the Carterville area ranged from 10 to 400 barrels of oil. The pressures dropped rapidly due to close spacing and variable sand conditions, so that most of the wells have been pumped for a greater part of their history.

Apparently any well above the −2,290-foot contour on the base of the Annona chalk in the Carterville oil area, which encountered sufficient porous sand in this horizon, was an oil well of some kind. Therefore it may be assumed that approximately 30 feet of oil column exists above the water level.

Wells drilled into this sand on the Carterville-Sarepta anticline but not on the local Carterville oil structure found non-porous sand or shale or porous sand containing salt water. This sand is practically depleted of its oil. The daily average production for 1937 was only 121 barrels per day from this sand in the Carterville oil area. All of

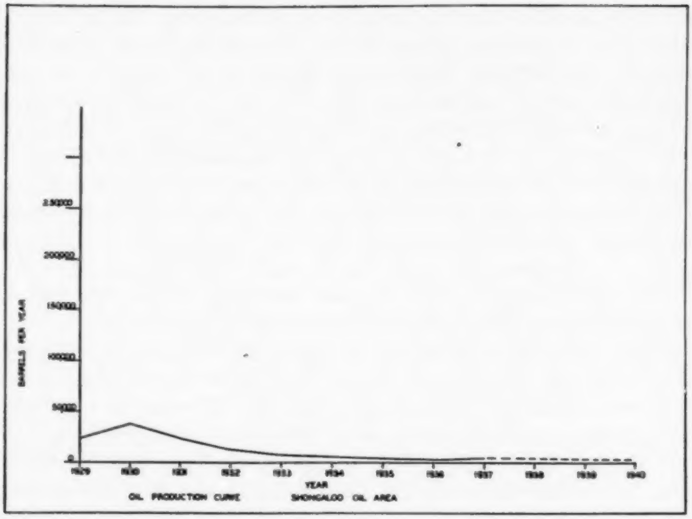


FIG. 6.—Oil production curve (Shongaloo oil area).

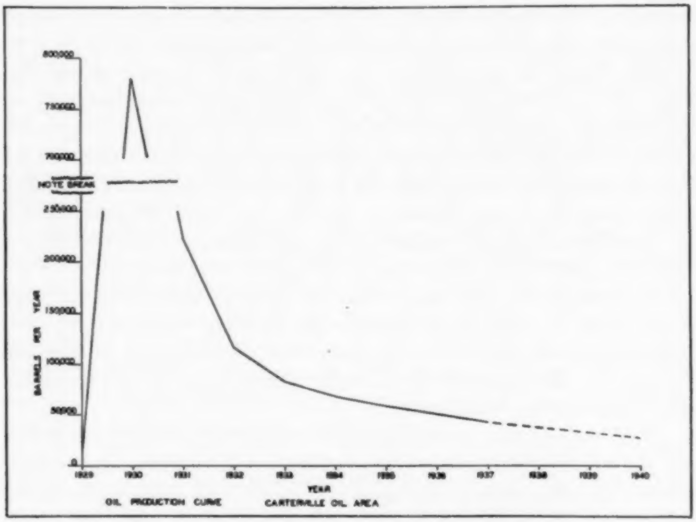


FIG. 7.—Oil production curve (Carterville oil area).

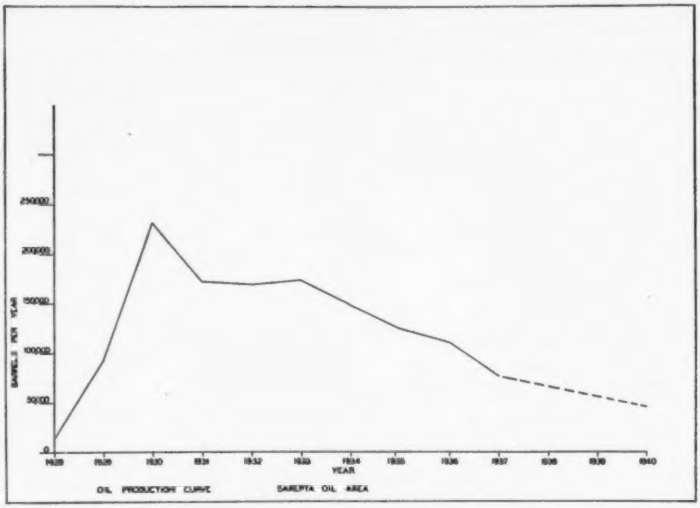


FIG. 8.—Oil production curve (Sarepta oil area).

the wells still producing are being pumped. Most of the oil wells are abandoned.

DEVELOPMENT AND PRODUCTION

The oil production curves (Figs. 7 and 8) and Tables III, IV, and V show the production of gas and oil from Carterville-Sarepta to January 1, 1938. A study of these curves and tables shows that the

TABLE III

SAREPTA. OIL PIPE-LINE RUNS

	Annual Production in Barrels	*Average per Month in Barrels*
1928	10,462	872
1929	92,240	7,686
1930	232,256	19,355
1931	172,832	14,403
1932	169,926	14,160
1933	174,069	14,505
1934	148,922	12,410
1935	124,864	10,405
1936	110,595	9,216
1937*	75,166	6,264
Total to January 1, 1938	1,311,932	

* December, 1937, production estimated.
Future life of field = 8 years estimated (to 1945).
Total reserve = 450,000 barrels estimated.

TABLE IV

CARTERVILLE, OIL PIPE-LINE RUNS

	Annual Production in Barrels	*Average per Month in Barrels*
1929	10,464	2,616 (for 4 months)
1930	779,351	64,946
1931	224,358	18,696
1932	115,424	9,617
1933	83,285	6,940
1934	68,821	5,735
1935	58,151	4,846
1936	51,077	4,256
1937*	43,702	3,642
Total to January 1, 1938	1,434,633	

* December, 1937, production estimated.
Future life of field = 8 years estimated (to 1945).
Total reserve = 229,000 barrels estimated.

TABLE V

GAS PRODUCTION FIGURES
CUMULATIVE TO JANUARY 1, 1938

	Cubic Feet
Shongaloo	70,991,134,000
Carterville	16,954,464,000
Sarepta	25,561,214,000
FOR YEAR 1937	
Shongaloo	162,136,000
Carterville	none since prior to 1934
Sarepta	none since 1935

recovery per acre of gas and oil has been small and that the development costs of this field were undoubtedly greater than the value of the gas and oil recovered.

The oil areas were developed on the basis of 10-acre spacing, which is too close and one reason for the lack of economic value of the field. The gas areas were developed without any definite spacing but generally on the basis of one well to 40 acres. To date, 86 gas wells, 112 oil wells, and 68 dry holes have been drilled in the producing areas at Carterville-Sarepta, and immediately surrounding them.

Standard rotary drilling rigs in use at the time throughout the Gulf Coastal Plain were used. Wooden derricks were generally used in preference to steel, because of the low cost of lumber. The present accurate systems of coring and well measuring as well as sampling were not in use at that time and the Schlumberger method was not

TABLE VI

CARTERVILLE-SAREPTA FIELD. PERTINENT DATA

Age—16 years

Productive Area

	Acres
Carterville gas	2,720
Sarepta gas	1,120
Total gas	3,840
Carterville oil	720
Sarepta oil	570
Total oil	1,290

Total production to January 1, 1938

	Cubic Feet
Carterville gas	16,954,464,000
Sarepta gas	25,561,214,000
Total gas	42,515,678,000
	Barrels
Carterville oil	1,434,633
Sarepta oil	1,311,932
Total oil	2,746,565

1937 production—gas, none

	Barrels
Carterville oil	43,702
Sarepta oil	75,166
Total oil	118,868

Number active wells—none

Number completed wells

	Carterville	Sarepta	Total
Gas	73	13	86
Oil	82	30	112
Dry	49	19	68
Total	204	62	266

Producing formations

	Depth in Feet	Thickness in Feet
Buckrange sand	2,680	12
Tokio gas sand	3,050	10
Tokio oil sand	3,150	7

Initial reservoir pressure—1,000–1,250 pounds

Production per acre to date

Buckrange oil sand	2,302 barrels
Tokio oil sand	1,992 barrels
Gas sand	11,071,800 cubic feet

Gravity of oil

Buckrange	26° Bé.
Tokio	39.4°–43° Bé.

used in well surveying; therefore, the measurements and logs are inaccurate. This accounts for most of the minor structural irregularities on the structure map (Fig. 4) and on the cross section (Fig. 5).

There were not as many blow-outs here as at Shongaloo, due to experience gained at Shongaloo, and the slower development which took place at Carterville-Sarepta.

Methods of setting casing and producing the wells in this field are not of interest because no unusual procedures were followed. They were not all those which are now considered best practice.

PIPE LINES. SHONGALOO AND CARTERVILLE-SAREPTA

The Union Producing Company (United Gas System) has a 12-inch gas line south from Carterville-Sarepta and Shongaloo connecting with its main north Louisiana gathering system. The Arkansas-Louisiana Gas Company has one 14-inch gas line which extends west through Shongaloo and Carterville-Sarepta, and connects with its gathering system for north Louisiana. The Arkansas-Louisiana Pipe Line Company continues to take some gas from the few producing gas wells in Shongaloo. The Northwest Louisiana Gas Company has a 4-inch gas line south and a 6-inch gas line east from Shongaloo. This company served some cities and towns in north Louisiana with gas from this field, but takes very little gas at present from Shongaloo and none from Carterville-Sarepta.

At present the Union Producing Company is not taking gas from these fields. Should the present deep test at Shongaloo find gas production from horizons below the Buckrange the present gas lines would give adequate outlet for the fields.

The Magnolia 4-inch oil line from Sarepta through Shongaloo is taking the oil from the only well producing oil in Shongaloo at present. This line also serves the Sarepta oil area of Carterville-Sarepta. The Carterville oil area is served by the Standard Oil Company of Louisiana's 4-inch line which connects to its main oil line at Haynesville.

SUBSEQUENT NOTE

(May 4, 1938)

The Shongaloo deep test, the Magnolia Petroleum Company's Sexton No. 1, now drilling in Sec. 32, T. 23 N., R. 9 W., at a depth of 9,756 in the Cotton Valley formation, has given further information on the Comanche and possibly older beds of these two areas.

The following are tentative correlations at this well from Schlumberger survey and samples.

	Depth in Feet
Surface elevation	225
Top of Glen Rose anhydrite	4,175
Base of Glen Rose anhydrite	4,652
Top of Travis Peak	5,700
Top of Cotton Valley	7,578
In Cotton Valley	9,756 (Present depth)

The only important showings in the section below the Tokio gas and oil sands have been in the Cotton Valley formation. A sand body was cored from 8,989 to 9,082 feet with gas and distillate showings throughout. It appears calcareous in streaks but has some porosity. This possible pay sand has not yet been tested, because it is planned to drill the well to the Smackover limestone if possible before thorough tests are made. This sand does not correspond with the Bodcaw sand, the gas-distillate producing sand of Cotton Valley. The Bodcaw sand at Cotton Valley is 550 feet below the top of the Cotton Valley formation whereas the thick sand at 8,989–9,082 in the Sexton well is 1,384 feet below the top of the Cotton Valley formation. In the Sexton well the Bodcaw sand is believed to have been penetrated from 8,038 to 8,058 but was calcareous and non-porous. From present indications the sand from 8,989 to 9,082 in the Sexton well should produce gas and distillate in commercial quantities.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1504-1518, 4 FIGS.

SUGAR CREEK FIELD, CLAIBORNE PARISH, LOUISIANA[1]

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ABSTRACT

The Sugar Creek oil and gas field, discovered in March, 1930, is located in Claiborne Parish, Louisiana. At present, it has a producing area of about 4,000 acres.

The structure controlling the accumulation of oil and gas in the field is an anticlinal dome about 5 miles long and 3 miles wide. The Upper Cretaceous structure conforms closely to that of the Comanche, but is much flatter. Dips on the beds of the structure steepen sharply toward the west, south, and southeast. The structure flattens toward the northeast, as it enters a synclinal saddle which forms the closure on that side. The dome is largely the result of deformation at the close of the Comanche and during the late Eocene period.

Gas is produced from two reservoirs in the Trinity group locally designated the Kilpatrick and the Darrett zones. Oil in commercial quantities is found only in the Darrett zone.

The Kilpatrick gas zone, which ordinarily is found immediately below the base of the "Massive anhydrite" of the Glen Rose group, consists of soft, porous, oölitic, gray limestone. The Darrett zone includes the transition beds between the lower Glen Rose formation above and the underlying Travis Peak, and also the upper 150 feet of the Travis Peak formation. It is composed chiefly of fossiliferous and oölitic limestones, red and gray sandstones, shales, and siltstones.

As of January 1, 1938, total cumulative gas production from the Sugar Creek field amounted to approximately 33 billion cubic feet. Production of oil to the same date totaled 86,000 barrels.

Present drilling activity in the field consists of two tests. One well, located near the top of the structure, is drilling at a depth of 9,800 feet, having already penetrated more than 2,000 feet of "lower Marine" Trinity black shales. The other well, located on the southwestern flank of the dome, is drilling in the lower Glen Rose.

LOCATION AND EXTENT

The Sugar Creek oil and gas field is located in the southeastern part of Claiborne Parish, Louisiana. The highest part of the structure centers in Sec. 6, T. 19 N., R. 5 W. The field received its name from Sugar Creek, which drains the area. The Homer oil field is situated about 15 miles northwest and the recently developed Lisbon oil field is about 6 miles northeast.

At present, the field covers an area of approximately 4,000 acres, being about 3 miles long and 2 miles wide.

HISTORY

The first test on the Sugar Creek structure was drilled by Fuller and Carnahan in 1920, the year following the discovery of oil in the Homer field. It was located on the McBryde farm in the NE. ¼ of

[1] Written, February 4, with the permission of John S. Ivy; presented by title before the Association at New Orleans, March 18; received by the editor, June 25, 1938.

[2] Union Producing Company.

Sec. 6, T. 19 N., R. 5 W., about 1,700 feet northwest of a "lower Marine" Trinity test now drilling below 9,800 feet. The McBryde well was abandoned at a total depth of 3,000 feet, after obtaining a showing of gas at an unknown depth. A second test was drilled by Fuller and Carnahan about 250 feet north of the first well, but was abandoned at an even shallower depth.

The apparently high structural position of the McBryde well, together with its showing of gas, led to the drilling of ten more tests in this area, to depths ranging from 2,800 to 3,400 feet. Most of these wells obtained small showings of gas and one well tested salt water, some gas, and a small showing of oil. Although these tests resulted in no production, they did indicate a pronounced structural "high" centering in Sec. 6, T. 19 N., R. 5 W.

In 1924, after the surface and subsurface geology of the area had been studied by J. Y. Snyder, the Sugar Creek Syndicate, Inc., obtained a block of leases covering a large part of the present field. The syndicate drilled six shallow tests on the block, one of which penetrated the Nacatoch formation, one was completed just below the base of the Annona chalk, and four were drilled into the Buckrange sand.

The first Lower Cretaceous exploration in the Sugar Creek area was initiated in August, 1925, when the Triangle Drilling Company drilled Keen No. 1, in the SE. $\frac{1}{4}$ of Sec. 7, T. 19 N., R. 5 W., to a total depth of 4,662 feet, where it was abandoned because of mechanical difficulties. This well obtained salt water and a considerable showing of 31.5° Bé. oil at a depth of 4,507 feet, just beneath the "Massive anhydrite" of the Glen Rose group.

Prior to the drilling of the Kilpatrick gas well, the Standard Oil Company of Louisiana and the Louisiana Gas and Fuel Company (now the Union Producing Company) each purchased an undivided $\frac{1}{3}$ interest in the Sugar Creek Syndicate's block of leases. These companies entered into a working agreement for the development of the Sugar Creek field. Since then, all drilling in the field has been conducted by these three companies, with the exception of the dry hole drilled by Lyons and Neely, which was located in Sec. 32, T. 20 N., R. 5 W.

After 10 years of exploratory drilling, the first commercial gas produced in the Sugar Creek area was obtained on March 6, 1930, when the Triangle Drilling Company completed Kilpatrick No. 1, in Sec. 7, T. 19 N., R. 5 W., at a total depth of 4,540 feet. The initial open flow of this well was 1,460,000 cubic feet per day and its initial closed pressure was 1,750 pounds per square inch. Since the com-

pletion of the discovery well, ten additional gas wells, which had initial open flows as high as 43 million cubic feet per day, and two dry holes have been completed in the Kilpatrick gas zone.

In November, 1935, the drilling of a "lower Marine" Trinity test was commenced. This well was Addie Darrett No. 2, in the SW. ¼ of Sec. 31, T. 20 N., R. 5 W. Sands containing gas were cored between 5,600 and 5,700 feet, at the top of the Travis Peak formation. The well was drilled to a total depth of 8,616 feet, having penetrated about 700 feet of the "lower Marine" Trinity black shale and sand section. At that depth, the drill pipe was stuck, and because of this mechanical difficulty, further drilling was impossible. The hole was plugged back to the Travis Peak gas sands, resulting in its completion as a large gas well at a depth of 5,703 feet.

This discovery, together with the decline in production of the Kilpatrick wells, initiated a program of deepening these gas wells to the newly discovered Darrett zone. At this time, nine of the eleven Kilpatrick wells have been deepened, resulting in the completion of six gas wells and three oil wells. In addition, two dry holes, on the eastern side of the field, have been drilled.

The three oil wells which were completed in the Darrett zone are: W. Brown No. 1, Sec. 1, T. 19 N., R. 6 W., completed flowing 205 barrels of oil in 24 hours through ½-inch tubing choke, from a total depth of 5,743 feet; Dobbins No. 1, Sec. 12, T. 19 N., R. 6 W., completed at a depth of 5,670 feet; and Carter No. 1, brought in flowing 431 barrels of oil in 18 hours through ⅜-inch tubing choke, from a total depth of 5,748 feet. The Brown and Dobbins wells are producing oil from the upper part of the Darrett zone, while Carter No. 1 is producing from a sand lens near the base of the zone.

Physiography

The topography encountered in the Sugar Creek area presents as much natural scenic beauty as any similar area in northern Louisiana. As a whole, the area resembles a large bowl. The central basin which forms the floor of the bowl has resulted from the erosion of the soft Cook Mountain sands that overlie the top of the structure. The more indurated Cockfield formation has resisted erosion and now caps the numerous high hills that surround the structure. The maximum relief is approximately 175 feet, with elevations ranging from 200 to 375 feet.

The surface is drained toward the northeast by numerous tributaries of Sugar Creek, which in turn flows north into Bayou D'Arbonne.

TABLE I

THE SUGAR CREEK FIELD

CLAIBORNE PARISH, LOUISIANA

GENERALIZED SECTION OF FORMATIONS

SYSTEM	SERIES	GROUP	FORMATION	THICKNESS	CHARACTER
TERTIARY	EOCENE	CLAIBORNE	COCKFIELD	0 To 20'	Lignitic yellowish brown sands and clays.
			COOK MOUNTAIN (MINDEN)	50' To 300'	Sands and ferruginous clays. In places fossiliferous and glauconitic.
			SPARTA	400' To 450'	Non-calcareous and non-fossiliferous reddish and light colored sands with thin shale partings.
			CANE RIVER	175' To 200'	Glauconitic sand and clay with ferruginous concretions.
			WILCOX	500' To 550'	Lignitic sands and clays.
			MIDWAY	550' To 625'	Gray to dark bluish gray shale with siderite concretions Calcareous in lower part.
Unconformity					
CRETACEOUS	UPPER CRETACEOUS (GULF SERIES)		ARKADELPHIA	25' To 50'	Gray calcareous clay and chalk. Fossiliferous.
			NACATOCH	175' To 225'	Broken sand, lime and shale. Fossiliferous.
		CHALK	SARATOGA	280' To 300'	Hard gray and white fossiliferous chalk.
			MARLBROOK MARL		Light to dark gray chalky shale and marl. Fossiliferous.
			ANNONA		Hard white fossiliferous chalk.
			OZAN	210' To 250'	Gray calcareous shale with sandy parts.
			BUCKRANGE	20' To 60'	Glauconitic sand
			BROWNSTOWN - TOKIO	600' To 700'	Sands, shales and limes.
			"WOODBINE"	75' To 125'	Red shales and sandy shales.
	Unconformity				
	LOWER CRETACEOUS (COMANCHE)	TRINITY	POST GLEN ROSE TRINITY REDS	175' To 225'	Limes and red and gray shales
			UPPER GLEN ROSE	150' To 200'	Limes and dark gray calcareous shales.
			GLEN ROSE ANHYDRITE ZONE	500' To 570'	Anhydrite, lime and shale.
			LOWER GLEN ROSE	1065' To 1140'	Lime, shale and sand with lime and sand predominating in upper part and shale and lime in lower part.
			TRAVIS PEAK	"TRANSITION ZONE" 55' To 65'	Red shales and sands with fossiliferous limes and black shales.
				2250' To 2350'	Red and gray sands and shales, lignitic in places. Contains hard quartzitic sands in lower part.
			UNCLASSIFIED PRE-TRAVIS PEAK MARINE BEDS	2000'+	Fossiliferous black shales containing beds of hard gray calcareous sands.

STRATIGRAPHY

Table I shows a generalized section of the formations of the Sugar Creek field.

EOCENE SERIES

CLAIBORNE GROUP

Cockfield formation.—The youngest Eocene formation exposed in the area is the Cockfield, composed principally of lignitic yellowish brown sands and clays. Only a few feet of this formation covers the tops of some of the hills in the area.

Cook Mountain.—The Cook Mountain (Minden) consists largely of ferruginous clays and sandstones. Greenish to grayish brown fossiliferous shales of this formation commonly contain concretions and beds of limonite. Here and there glauconitic sands and shales are present. This formation varies from 50 to 300 feet in thickness.

Sparta.—The Sparta is composed of thick beds of reddish and buff-colored unconsolidated sands with relatively thin shale or sandy shale partings. The formation is non-calcareous and non-fossiliferous and commonly contains limonitic concretionary beds. The Sparta has a thickness ranging from 400 to 450 feet.

Cane River formation.—The Cane River, the basal member of the Claiborne group, is bluish to greenish brown glauconitic sandy clay containing ferruginous concretions. No large fossils are found in these beds.

Wilcox formation.—Consisting chiefly of cross-bedded gray and brown sands and sandy shales, with thin beds of lignite, the Wilcox is lithologically similar to the Sparta. The Wilcox has a thickness of about 525 feet in this area.

Midway formation.—The Midway varies from 550 to 625 feet in thickness and consists of gray to dark bluish gray fossiliferous clay with numerous sideritic concretions. In well logs it is commonly recorded as shale and boulders. The Midway is the basal formation of the Eocene series and lies unconformably on the Upper Cretaceous (Gulf series).

UPPER CRETACEOUS (GULF SERIES)

A well developed section of the Upper Cretaceous series has a thickness of approximately 1,500 feet in this area.

Arkadelphia formation.—The Arkadelphia is composed of gray calcareous clay and chalk, varying in thickness from 25 to 50 feet. This topmost member of the Upper Cretaceous is separated from the Eocene Midway by an unconformity, shown by a faunal change rather than by one in lithologic character or structure.

Nacatoch formation.—This formation is made up of broken sandstone and limestone in the upper part and shale in the lower part. Its thickness ranges from 175 to 225 feet.

Chalk group (*"Chalk series"*).—The chalk group, with a thickness of about 300 feet, is divided into the Saratoga chalk, the Marlbrook marl, and the Annona chalk. The Saratoga, at the top of the group, is hard gray and white fossiliferous chalk, which is sandy in places. The Marlbrook consists of light to dark gray fossiliferous chalky shales and marls. The Annona is gray to white massive fossiliferous chalk, locally becoming clayey.

Ozan formation.—The Ozan is dark gray micaceous calcareous clay, with sandy streaks. Its thickness varies from 210 to 250 feet. Some of the wells in the field penetrated several feet of porous sand or sandy beds in the top of the Ozan just beneath the Annona chalk.

Buckrange formation.—This formation consists of 20 to 60 feet of greenish gray calcitic sandstone containing a few shell fragments.

Brownstown-Tokio formation.—Beneath the Buckrange is found about 700 feet of formation composed of gray clay with streaks of limestone and light gray glauconitic micaceous sandstone.

"Woodbine" formation.—The basal member of the Upper Cretaceous consists of mottled purple and gray sandstone and clay, ashy sandstone and sandy clay, and very fine-grained light gray sandstone. Numerous sideritic nodules are found near the top. Its thickness varies from 75 to 125 feet. It is probably equivalent to the "Woodbine" as used by Dane, in Arkansas.

LOWER CRETACEOUS (COMANCHE SERIES)

TRINITY

More than 6,300 feet of the Lower Cretaceous Trinity, penetrated on the Sugar Creek structure, are described as follows.

Post-Glen Rose "reds."—The uppermost formation of the Trinity group consists of 175–225 feet of limestone, sandy limestone, dark gray shale, and red shale. An unconformity occurs between the top of this Lower Cretaceous formation and the Upper Cretaceous above.

Upper Glen Rose formation.—A bed of limestone and shale, with sandy streaks, occurs beneath the post-Glen Rose "reds." The thickness of the Upper Glen Rose is about 175 feet.

Glen Rose anhydrite zone.—The anhydrite zone of the Glen Rose has an average thickness of 525 feet on the Sugar Creek structure, being only a few feet more than that found in the Lisbon field 6 miles northeast and that penetrated in the Cotton Valley field 27 miles northwest. In the Sugar Creek area, the upper 200 feet of this zone

consists of limestones and shales with three thin stringers of anhydrite near the top. Beneath this is the 235-foot "Massive anhydrite" broken by partings of limestone and shale. Below the "Massive anhydrite" are found about 65 feet of fossiliferous limestones and black shales, with porous oölitic and honey-combed limestone at the top. A 25-foot bed of anhydrite, broken by thin streaks of shale and limestone, lies at the bottom of this zone.

Lower Glen Rose formation.—Below the anhydrite zone are found approximately 1,100 feet of limestones, shales, and sandstones, with limestone and sandstone predominating in the upper part and shale and limestone in the lower part. Three streaks of limestone, each 8–10 feet in thickness, occur at about 155–200 feet above the base of the lower Glen Rose formation. This limestone zone, referred to as the "Three-Fingered lime," is very pronounced on Schlumberger surveys of all wells in the field, and accurately reflects the structure on the top of the Travis Peak formation.

There is a zone of transitional change from the marine beds of the Glen Rose to the non-marine deposits of the Travis Peak beneath. The upper part of this zone, which is 55–65 feet in thickness, consists of red and black shales, reddish and greenish gray siltstones and brown sandstones and sandy shales. The lower part is composed of oölitic and fossiliferous limestones with streaks of black shale and gray sandstone.

Travis Peak (pre-Glen Rose "reds") formation.—This formation is composed of 2,250–2,350 feet of red and gray sandstones and shales, with a few streaks of lignite. The sandstones become very hard and dense near the bottom.

The so-called "Travis Peak" of Louisiana differs greatly from the type section of the Travis Peak formation of Texas. There is a possibility that the pre-Travis Peak marine black shales of Louisiana are equivalent to the "lower Marine" beds of the Travis Peak in Texas.

Unclassified pre-Travis Peak marine beds.—More than 2,000 feet of fossiliferous black shales containing beds of hard gray calcareous sandstones have been penetrated, the lower 900 feet of which consist almost entirely of black shale.

Structure

The structure controlling the accumulation of oil and gas in the Sugar Creek field is an anticlinal dome about 5 miles long and 3 miles wide. It is expressed at the surface as an imperfect inlier of the Cook Mountain formation surrounded by the overlying Cockfield formation, accounting for the bowl-like topography of the area.

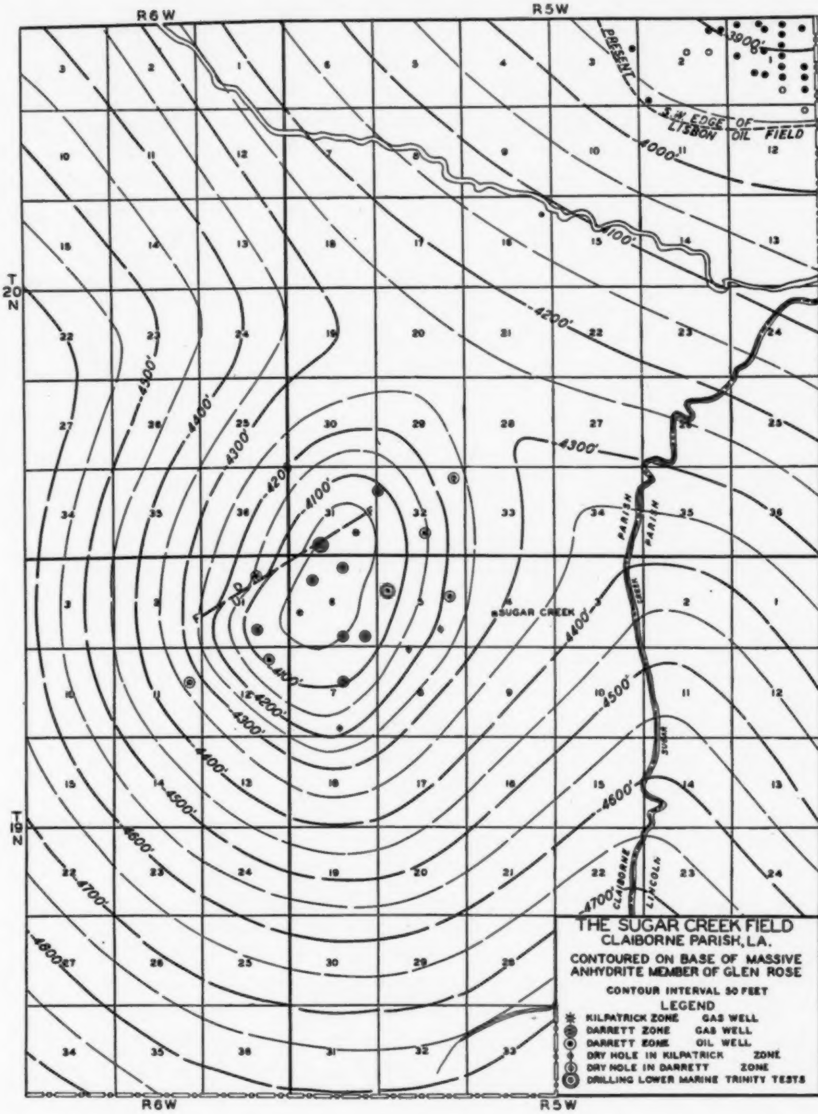

FIG. 1.—Sugar Creek field contoured on base of "Massive anhydrite." Contour interval, 50 feet.

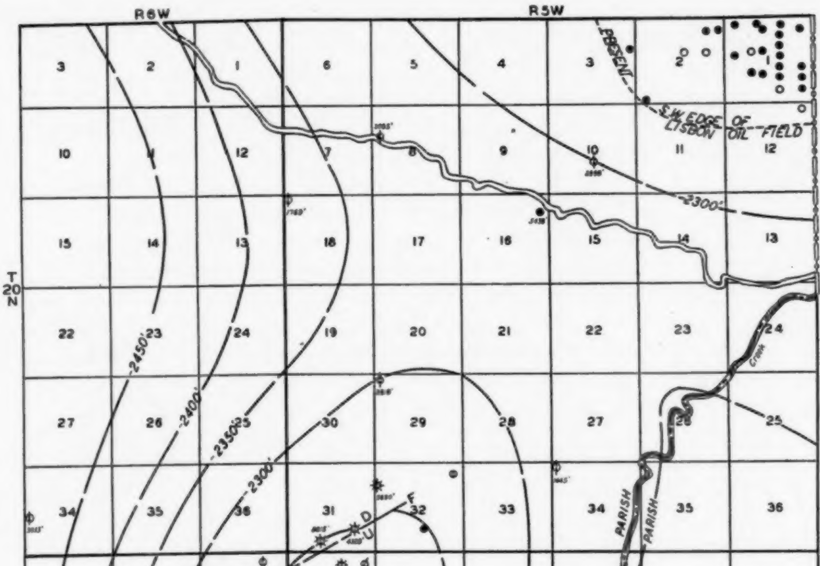

FIG. 2.—Sugar Creek field contoured on base of Annona chalk. Contour interval, 50 feet.

The subsurface structure is depicted by two structure-contour maps (Figs. 1 and 2), an isopach map (Fig. 3), and a northeast-southwest section through the center of the field (Fig. 4). Figure 1 portrays the Comanche structure; the datum is the subsea depth of the base of the "Massive anhydrite" formation of the Glen Rose group. The Upper Cretaceous structure is presented in Figure 2 which is a contour map showing the configuration of the base of the Annona chalk. The Upper Cretaceous structure conforms closely to that of the Comanche, but is much flatter. Dips on the beds of the former are only 60 feet to the mile, while those on the latter are about 160 feet per mile. The dips steepen sharply on the flanks of the structure toward the west, south, and southeast. The structure flattens northeast, as it enters a synclinal saddle which forms the closure on that side.

Figure 3 is an isopach map showing the variation in the interval from the base of the Annona chalk to the base of the "Massive anhydrite" of the Glen Rose and indicates considerable thinning of that section on the top of the structure.

The structure is not materially complicated by faulting. The presence of one normal fault, having a throw of about 20–25 feet, has been inferred because of the apparent structural position of certain wells. This fault is downthrown toward the northwest and strikes northeast across the top and west side of the structure.

The Sugar Creek structure is largely the result of deformation at the close of the Comanche and during the late Eocene period. Its proximity to known salt domes on the south suggests that it may be a deeply buried salt dome.

Figure 4 is a northeast-southwest section through the center of the field. This section of Schlumberger electrical logs shows the relative positions of the beds containing the two producing horizons of the field.

Producing Zones

Kilpatrick zone.—This reservoir is soft, porous, oölitic, gray limestone in which small cavities occur. It has an average thickness of 13 feet, ranging from 6 to 18 feet. Its porosity varies from 14 to 23 per cent, averaging about 18 per cent. It generally occurs immediately beneath the base of the "Massive anhydrite" of the Glen Rose, although in some places a parting of 2–6 feet of dense, gray limestone or black shale separates the porous gas horizon from the anhydrite above. Although oil-stained cores have been obtained, no oil in commercial quantities has been produced from this reservoir.

The largest initial daily open flow of any Kilpatrick zone well was 43,330,000 cubic feet of gas, obtained from the Hodges No. 1, in the

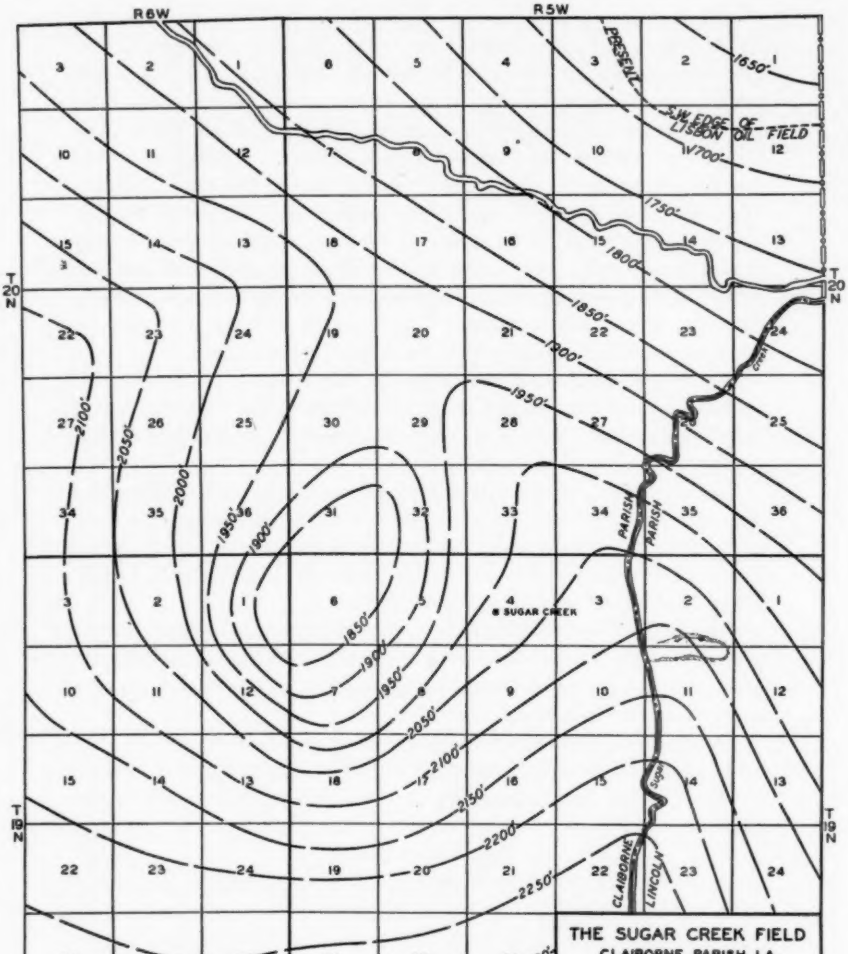

FIG. 3.—Sugar Creek field isopach map, base of Annona chalk to base of "Massive anhydrite." Contour interval, 50 feet.

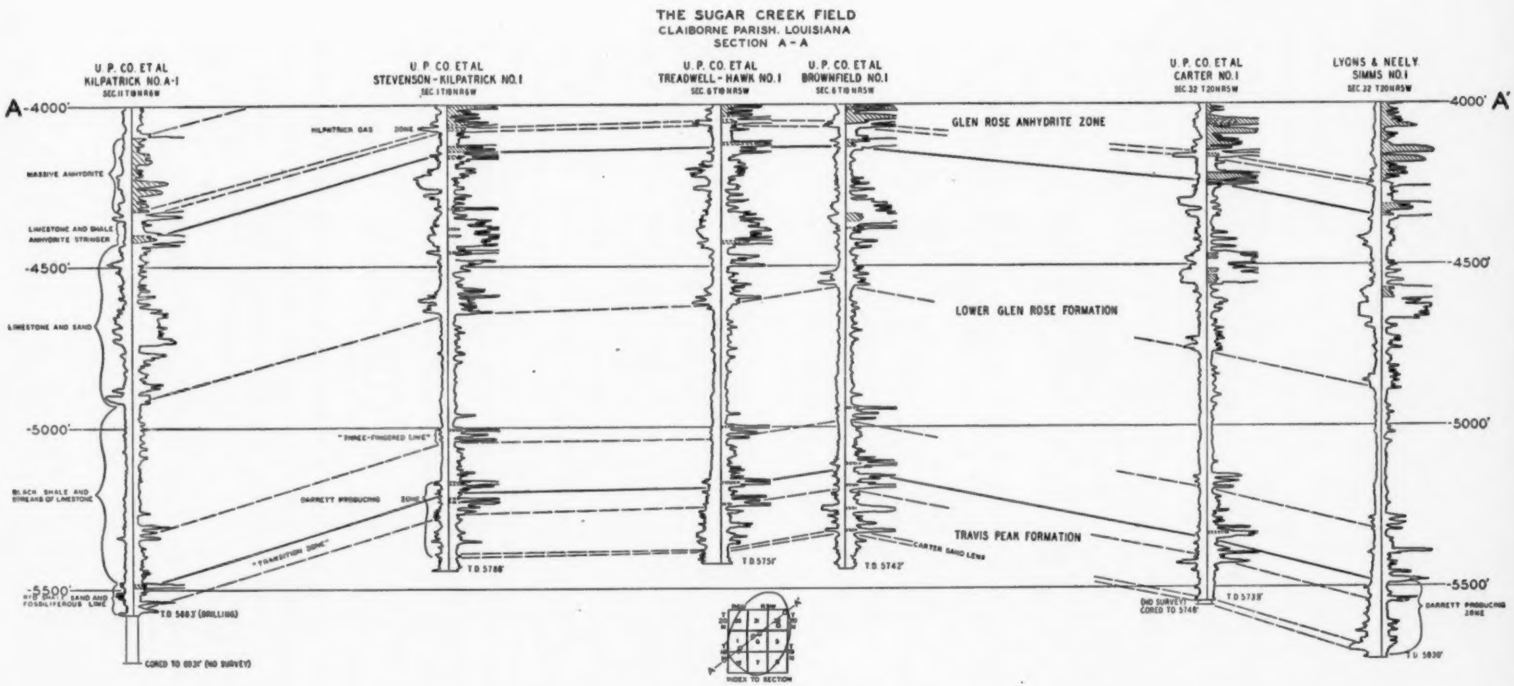

Fig. 4.—Schlumberger section *AA'*, Sugar Creek field.

SW.¼ of Sec. 6, T. 19 N., R. 5 W. The initial closed pressure of the first five wells completed in the Kilpatrick zone varied between 1,750 and 1,800 pounds. Wells drilled 10–12 months later had closed pressures ranging from 1,600 to 1,640 pounds. The present closed pressure of the two remaining Kilpatrick wells is about 350 pounds per square inch.

Pipe-line facilities to serve the field were placed in operation January 16, 1931, and wells completed in this zone have produced a total of about 28 billion cubic feet of gas to January 1, 1938.

Character of gas.—An analysis of the gas from the Kilpatrick reservoir is as follows.

	Per Cent
Carbon dioxide	.30
Methane	88.35
Ethane	5.37
Propane	2.05
Butane	1.45
Pentane and heavier	.85
Nitrogen	1.63
	100.00
Specific gravity (calculated)	.6499
B.T.U. (wet)	1103

Darrett zone.—In this zone gas and oil occur in porous beds distributed throughout a thickness of 175–275 feet. This zone includes the transition beds between the lower Glen Rose formation above and the underlying Travis Peak, ordinarily 55–65 feet in thickness; it also includes the upper 150 feet of the Travis Peak formation. The transition zone comprises a group of dense gray fossiliferous limestones, hard red and gray sandstones, and black and red shales. The Travis Peak consists characteristically of red and gray sandstone interbedded with red shale and siltstone. The porosity within the zone is variable and the character of the wells drilled is dependent on the nature and total thickness of the porous beds encountered.

The daily open-flow capacities of gas wells completed in this zone vary from 5 million cubic feet to as high as about 100 million cubic feet. The average initial closed pressure of early wells was about 2,300 pounds.

Oil is being produced from two members of this zone. The "Carter sand lens" is a porous bed of sand near the base of the Darrett zone and is so named because it is productive in the Carter No. 1, Sec. 32, T. 20 N., R. 5 W., on the east side of the field. On the west side of the field oil is produced in the W. Brown No. 1 and Dobbins No. 1 from limestones and sandstones in the upper part of the zone.

Character of gas.—An analysis of the gas from the Darrett zone is here given.

	Per Cent
Carbon dioxide	.60
Methane	91.88
Ethane	4.47
Propane	1.70
Butane	.94
Pentane and heavier	.31
Nitrogen	.10
	100.00
Specific gravity (calculated)	.620
B.T.U. (wet)	1076

Character of oil.—The following is a summary of an analysis of the oil obtained from the Carter No. 1.

Gravity	34.7° Bé.
Color	Dark brown

	Per Cent	*Gravity °Bé.*
Gasoline	15	61.7
Naphtha	10	49.5
Kerosene	20	43.1
Bottoms	55	12.6

Tests of the oils produced from the three Darrett zone wells showed the following gravities.

	Gravity °Bé.
Dobbins No. 1	37.0
Carter No. 1	34.7
Brown No. 1	32.4

Darrett gas production.—During 1936 and 1937, nine gas wells, three oil wells, and two dry holes were completed in the Darrett zone. With one exception, all of the wells completed as producers in the latter were deepened from the Kilpatrick zone from which they had produced gas. As of January 1, 1938, about 5 billion cubic feet of gas had been withdrawn from the Darrett zone.

Present Drilling Activity

At this date, February 4, 1938, two deep tests are being drilled in the Sugar Creek field. The Kilpatrick No. A-1, Sec. 11, T. 19 N., R. 6 W., on the southwest flank of the structure, is drilling at 5,400 feet, in the lower Glen Rose formation. The Brownfield No. 2, Sec. 5, T. 19 N., R. 5 W., near the top of the structure, is drilling at 9,800 feet, having already penetrated more than 2,000 feet of "lower Marine" Trinity black shale, described as follows.

Depth in Feet	
7,790–8,175	Black fossiliferous shale
8,308	Hard dense to slightly porous gray to tan, fine-grained sandstones with partings of black shale
8,400	Black shale with calcareous streaks
8,430	Calcareous and shaly sandstone
8,475	Black shale and fossiliferous limestones
8,860	Hard dense to slightly porous gray calcareous sandstones, with streaks and partings of black shales, fossiliferous limestones and a few thin beds of small quartz pebbles
9,800	Black shale with a few calcareous and fossiliferous streaks

The sand zone occurring between 8,175 and 8,308 feet had showings of gas in the more porous parts. Porosities varied from 2 to 9 per cent, and permeabilities were almost zero. This zone is probably the equivalent of the deep producing gas zone in the Cotton Valley field located in T. 21 N., R. 10 W. The sand section between 8,475 and 8,860 feet also had showings of gas in its more porous streaks. Porosities of this section ranged from 2 to 16 per cent, with only a few thin beds having more than 10 per cent. Permeabilities were, for the most part, less than one millidarcy. This zone probably corresponds with the sands penetrated between 5,400 and 5,800 feet in the Morgan-Smith No. 2, deep test in the Bellevue field, located in Sec. 22, T. 19 N., R. 11 W.

PRODUCTION

Production statistics.—Table II shows the metered production of gas from the Sugar Creek field by years.

TABLE II

Year	*Total Number of Wells Producing During Year*	*Metered Gas Withdrawals in Thousand Cubic Feet at 10 Ounces, 14.4 Pounds Pressure*	
		For Year	*Cumulative at End of Year*
1931	6	3,771,193	3,771,193
1932	8	3,950,719	7,721,912
1933	10	3,761,842	11,483,754
1934	11	4,244,951	15,728,705
1935	11	5,715,764	21,444,469
1936	11	5,450,452	26,894,921
1937	14	5,141,222	32,036,143

Including estimated lost gas, the total accumulated gas produced from the field on January 1, 1938, amounted to about 33 billion cubic feet. Total accumulated oil production on January 1, 1938, was 86,000 barrels, all of which was from the Darrett zone.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1519-1559, 3 FIGS.

STRATIGRAPHY AND STRUCTURAL HISTORY OF EAST-CENTRAL UNITED STATES[1]

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ABSTRACT

This article contains a discussion of the regional stratigraphic changes as revealed from studies of outcrops and cuttings from approximately 525 wells in the following states: Michigan, Ohio, Indiana, Illinois, Kentucky, and Tennessee. Three west-east cross sections have been prepared in order to show graphically these structural and stratigraphic changes. A tentative correlation table and seven logs made from studies of well cuttings are included as an aid to future students in the area.

The structural history which began in pre-Cambrian time, continued with minor pulsations in post-Canadian, post-St. Peter, post-Brassfield, post-Chattanooga, post-St. Genevieve, and post-Pennsylvanian time. One major period of folding occurred in post-Mississippian pre-Pennsylvanian time.

INTRODUCTION

This article has been prepared primarily to summarize briefly some of the facts concerning the stratigraphy of Michigan, Ohio, Indiana, Illinois, Kentucky, and Tennessee.

Gas was discovered in Ohio in 1884, only 25 years after the completion of the Drake well in Pennsylvania. The production of oil reached a peak in 1904 and gradually declined from that time until the recent discoveries of new fields in Michigan and Illinois.

The cross sections were prepared in 1934 and 1935 in order to crystallize ideas on the regional features of the area by showing as many details of stratigraphy as possible. In the study of the general area, samples from approximately 525 wells were examined microscopically. This sample information, which unfortunately was very sketchy in Ohio and Indiana, was supplemented wherever possible by information derived from selected drillers' logs and by some studies of the outcrops.

STRATIGRAPHY

PLEISTOCENE

Glacial drift, composed of granitic boulders, poorly consolidated sands, gravels, and yellow or gray clay, covers all or large parts of the

[1] Manuscript received, June 9, 1938.

[2] Consulting geologist, 1105 NE. Twentieth Street. The writer sincerely appreciates the whole-hearted coöperation extended by the geological surveys in the following states: Missouri, Illinois, Michigan, Ohio, Indiana, Kentucky, and Tennessee. He is truly grateful to many individuals composing the geological groups who have so materially aided in the solution of the problems encountered. The literature has been drawn upon freely, and titles of some of the more important articles are given as footnotes.

The writer is indebted to A. I. Levorsen, Ira H. Cram, and J. K. Knox for helpful suggestions as to the treatment of the subject, to Robert W. Haiges for the drafting and to the Phillips Petroleum Company for permission to publish the data.

TABLE I

TENTATIVE STRATIGRAPHIC CORRELATION

PENNSYLVANIAN

	Michigan	*Ohio*	*Indiana*	*Illinois*	*Western Kentucky*	*Eastern Kentucky*	*Eastern Tennessee*	*Western Tennessee*
Monongahela		Present			Present	Present	Absent	Absent
Conemaugh		Present	Present	McLeansboro formation	Present	Present	Absent	Absent
Allegheny	(?) Grand River	Present	Present	Carbondale formation	Present	Present	Absent	Absent
Pottsville	Saginaw	Present	Mansfield sandstone	Pottsville	Present	Present	Present	Absent

TABLE I (continued)
TENTATIVE STRATIGRAPHIC CORRELATION

MISSISSIPPIAN

			Michigan	Ohio	Indiana	Illinois	Western Kentucky	Eastern Kentucky	Eastern Tennessee	Western Tennessee
UPPER	Chesterian	Upper	Absent	Absent	Negli Creek Mt. Pleasant Bristow Siberia Wickliff Tar Springs	Kincaid-Clore Palestine Menard-Vienna Tar Springs	Kincaid-Clore Palestine Menard-Vienna Tar Springs	Pennington	Pennington	Absent
UPPER	Chesterian	Middle	Absent	Absent	Glen Dean Hardinsburg Golconda Indian Springs Cypress	Glen Dean Hardinsburg Golconda Cypress	Glen Dean Hardinsburg Golconda Cypress	Glen Dean Absent Golconda Cypress	Bangor Hartselle Golconda Cypress (Newman Group)	Absent
UPPER	Chesterian	Lower	Absent	Absent	Beech Creek Elwren Reelsville Sample Beaver Bend Mooretown Paoli	Paint Creek Yankeetown Renault Aux Vases	Paint Creek Sample Renault Aux Vases	Gasper	Gasper (Newman Group)	Absent
LOWER		Meramecian	Bayport Michigan	Maxville Absent	St. Genevieve St. Louis Spergen	St. Genevieve St. Louis Spergen	St. Genevieve St. Louis Spergen	Ohara Fredonia St. Louis Spergen	Ohara Fredonia St. Louis Spergen	Fredonia St. Louis Spergen
LOWER		Osagian	Marshall Coldwater	Logan Cuyahoga	Harrodsburg Borden New Providence	Warsaw Keokuk Burlington Fern Glen	Warsaw Fort Payne New Providence	Warsaw New Providence	Warsaw Fort Payne Grainger	Warsaw Fort Payne New Providence
LOWER		Kinderhookian	Sunbury Berea Bedford Antrim (Ellsworth in Western Michigan) (upper part)	Sunbury Berea Bedford Ohio (upper part)	Rockford New Albany	Chouteau Hannibal Louisiana Sweetland Creek	Chattanooga	Sunbury Berea Bedford Ohio (upper part)	Bigstone Gap Clinger	Ridge Top Chattanooga Hardin

TABLE I (continued)

TENTATIVE STRATIGRAPHIC CORRELATION

DEVONIAN

		Michigan	*Ohio*	*Indiana*	*Illinois*	*Western Kentucky*	*Eastern Kentucky*	*Eastern Tennessee*	*Western Tennessee*
UPPER		Antrim (lower part)?	Ohio (lower part)	Antrim in northern part	Cedar Valley Wapsipinicon	Duffin	Ohio (lower part)	Cumberland Gap	Absent
MIDDLE	Erian	Traverse	Olentangy Delaware	Sellersburg	St. Laurent Beauvais	Casey Sellersburg	Casey Boyle	Possibly some of the black shale is Erian and Ulsterian in age	Absent
	Ulsterian	Dundee	Columbus	Jeffersonville Pendleton	Grand Tower Dutch Creek Clear Creek	Jeffersonville (present only near Louisville)	Absent		Pegram
LOWER	Oriskanian	Oriskany (?)	Austinburg	Unknown	Little Saline	Absent	Oriskany		Camden Harriman Qualls
	Helderbergian	Detroit River Sylvania	Detroit River Sylvania	Detroit River Sylvania	Backbone Bailey	Probably similar to those of western Tennessee	Lower Helderberg	Absent	Decaturville Birdsong Olive Hill Rockhouse

TABLE I (continued)
TENTATIVE STRATIGRAPHIC CORRELATION

SILURIAN

		Michigan	*Ohio*	*Indiana*	*Illinois*	*Western Kentucky*	*Eastern Kentucky*	*Eastern Tennessee*	*Western Tennessee*
UPPER	Cayugan	Bass Island Salina	Bass Island Salina	Kokomo Salina	Cayuga (probably present) Absent	Cayuga Absent	Cayuga Salina	Hancock Absent	Decatur Absent
MIDDLE	Niagaran	(Guelph absent)? Engadine Manistique Rochester? Burnt Bluff	Absent? Niagara	Huntington Liston Creek Red Bridge	Port Byron Racine Waukesha Joliet	Louisville Waldron Laurel Osgood	Niagara Crab Orchard	Absent	Brownsport Lobelville Bob Beech River Dixon Lego Waldron Laurel Osgood
LOWER	Alexandrian	Cataract: Cabot Head Manitoulin	Brassfield (Clinton)	Mississinewa Brassfield	Kankakee Edgewood Girardeau Orchard Creek	Brassfield	Brassfield	Rockwood Clinch	Brassfield

TABLE I (continued)

TENTATIVE STRATIGRAPHIC CORRELATION

ORDOVICIAN

		Michigan	*Ohio*	*Indiana*	*Illinois*	*Western Kentucky*	*Eastern Kentucky*	*Eastern Tennessee*	*Western Tennessee*
UPPER	Cincinnatian	Richmond Maysville Eden Utica	Richmond Maysville Eden Utica	Richmond Maysville Eden Absent	Maquoketa Absent Absent Absent	Saluda Liberty Waynesville Arnheim McMillan Fairview Paintlick Million Fulton	Sequatchie Maysville Eden Absent	Sequatchie	Fernvale Arnheim Leipers Absent Absent
MIDDLE	Mohawkian	Trenton Black River	"Trenton"	"Trenton"	"Kimmswick" Decorah Platteville	Cynthiana Perryville Bigby Hermitage Tyrone	Similar to western Kentucky Chickemauga		Catheys Cannon Bigby Hermitage Tyrone } Low- Carters } ville
	Chazyan	Absent	Absent except possibly in southern Ohio	Absent except possibly in southern Indiana	Absent	Oregon Camp Nelson	Present?	Present?	Lebanon Ridley Pierce Murfreesboro
LOWER	Big Buffalo	St. Peter	Absent as sandstone	Absent as sandstone except in NW. Indiana	St. Peter	Absent as sandstone	Absent as sandstone	Absent as sandstone	Absent as sandstone
	Cana-dian	Prairie du chien	Prairie du chien	Prairie du chien	Shakopee New Rich-mond	Upper Knox	Upper Knox	Upper Knox	Upper Knox
	Ozar-kian				Oneota				

states considered in this paper with the exception of Kentucky and Tennessee. The drift attains its maximum thickness in northwestern Michigan, where approximately 900 feet have been penetrated, and thins toward the west, south, and east. In western Kentucky and Tennessee loess was deposited during Pleistocene time.

TABLE II

APPROXIMATE THICKNESS OF FORMATIONS IN FEET

Formation	*Michigan*	*Ohio*	*Indiana*	*Illinois*	*Kentucky*	*Tennessee*
Pennsylvanian	0– 570	0–2,200	0–1,175	0–2,260	0–3,000	0–4,500
Chester	0	0	0– 650	0–1,515	0–1,000	0– 340
Meramec	0– 500	0– 110	0– 410	0– 690	0– 550	0– 435
Osage	0–1,500	0– 800	0– 710	0–1,040	0– 850	0– 350
Kinderhook and Upper Devonian	0– 825	0–3,450	0– 410	0– 250	0– 990	0– 55
Middle Devonian	0–1,100	0– 170	0– 75	700	0– 120	0– 12
Lower Devonian and Upper Silurian	0–3,500	0–1,280	0– 140	0	0– 535	0– 450
Niagara and Cataract	720	0– 865	0– 735	0– 880	0– 575	0– 130
Cincinnati group	800	0–1,100	0– 815	0– 290	0– 800	0– 345
"Trenton" limestone	900	870	535	575	960	1,150
St. Peter sandstone	0– 155	0	0– 140	335	0	0
Lower Magnesian	?	860	860	535	730	410
Cambrian	?	470	1,675	2,300	?	?

PENNSYLVANIAN

One to 70 feet of red, fine to coarse, somewhat unconsolidated quartz sand with thin beds of gypsum and gray or red shales underlie nine counties in central Michigan. According to Kelly[3] these are young Pennsylvanian beds.

The Pennsylvanian rocks in the other states consist of gray or red variegated shales, thin coals, arkosic, fine-grained sandstones or coarse conglomerates and rare occurrences of thin, pure, or shaly limestones. In most places there is a thick sandstone or conglomerate at the base of the group. These clastic Pennsylvanian beds thicken from approximately 500 feet in the Michigan basin to more than 4,500 feet in the coal basin of eastern Tennessee. Since 3,000 feet is the maximum thickness in the western coal basin the eastern coal basin was deeper than the one in Illinois, Indiana, and western Kentucky.

The Beaver, Horton, Pike, Wages, Jones, and Epperson oil sands of Kentucky are Pennsylvanian in age. Lenticular as well as channel

[3] W. A. Kelly, "The Pennsylvanian System of Michigan," *Michigan Geol. Survey*, Ser. 34, Pub. 40 (1936), pp. 149–226.

sandstones of Pennsylvanian age are producing oil in 49 of the 80 oil fields in Illinois. The producing Goose Run, Mitchell, First Cow Run, Dunkard, Macksburg, Second Cow Run, Salt, and Maxton sands of Ohio are Pennsylvanian in age. In Indiana commercial production has been found in the following Pennsylvanian sands: Oaktown, Monroe City, Bridgeport, McRoberts, and West Princeton.

MISSISSIPPIAN

CHESTER GROUP

The Chester rocks are a series of gray or red, variegated shales, pure to shaly sandstones and finely crystalline, fossiliferous limestones. These rocks are absent in Ohio, Michigan, western Tennessee, central Kentucky, northern Illinois, and northern and eastern Indiana. In the eastern Tennessee basin the Chester attains a maximum thickness of 340 feet. From Kentucky and Tennessee it gradually thins northward toward Ohio where these beds were probably removed by pre-Pennsylvanian erosion. The Chester of the eastern basin may be divided into an upper shale, a middle sandstone and limestone, and a lower oölitic limestone which is conformable with the underlying St. Genevieve limestone of Meramec age.

The upper Chester of the western basin is predominantly red and gray shale and thin limestone, the middle less calcareous and more sandy and the lower member containing increasing amounts of limestone and red shale. The Chester shales which are not sideritic or so dark, are generally more fine-grained than those of the Pennsylvanian. The red clays do not seem to be so well developed on the south and east. The limestones are gray or brown, dense to crystalline, slightly oölitic and cherty, fossiliferous, and in many places contain sand grains. The arenaceous rocks are gray, pure to shaly or calcareous, porous to well cemented, angular, fine to medium-grained sandstones which are more uniformly assorted than those of the Pennsylvanian.

Except in Christian, Macoupin, Montgomery, Macon, Fayette, St. Clair, and parts of Randolph and Monroe counties, Illinois, the Chester rests conformably on the St. Genevieve in the western basin. The deepest part of the western Chester basin was in Gallatin County in southern Illinois, where 1,515 feet of alternating sandstone, shale, and limestone have been drilled. Since the maximum thickness of the Pennsylvanian is in western Kentucky, the deepest part of the western basin was much farther north in Chester time than it was during the deposition of the latter.

Chester sands are producing oil in 18 of the 80 oil pools in Illinois. In Kentucky most of the oil produced in Ohio, Caldwell, Christian,

McLean, Muhlenberg, Daviess, and Henderson counties comes from lenticular Chester sands. The Glen Dean limestone is known as the Oneida and the basal Chester Gasper oölite as the Glen Mary oil sand of eastern Tennessee.

MERAMEC GROUP

The upper, very persistent member of the Meramec group is the St. Genevieve limestone which is the Ohara or Fredonia limestone in the eastern basin of Kentucky and Tennessee, the Maxville limestone in Ohio, and the Bayport limestone in Michigan. The St. Genevieve is light gray, slightly oölitic, finely crystalline to dense limestone with fragments showing conchoidal fracture. In the western basin below the St. Genevieve is a more finely crystalline non-oölitic limestone containing streaks of mottled, gray to brown, opalescent, fresh to slightly weathered chert, anhydrite, and thin, granular dolomites. The top of this cherty zone has been used in well correlations as the top of the St. Louis limestone.

The Spergen is lithologically very similar to the St. Genevieve except that it is less oölitic. This limestone is richly fossiliferous, containing fragments of fenestellid bryozoans, low and high-spired gastropods, ornate ostracods, siliceous crinoid stems, brachiopods, and *Endothyra baileyi*, a foraminifer.

The oölites extend through the whole Meramec section; in eastern Kentucky and Tennessee, consequently, they are poor horizon markers. The equivalent Meramec beds are very different in Michigan, where they are a series of anhydrites, dolomites, limestones, and gypsiferous shales, characteristic of a shallow, restricted, inland sea in which the supply of water was only rarely augmented.

In Ohio, beds equivalent to the lower part of the Meramec and the upper part of the Osage are absent so that the Maxville unconformably overlies beds of the Logan group. Everywhere else in the area the Meramec may be considered as conformable with the Osage.

The Meramec thickens by addition of basal beds from 110 feet in Ohio to 280 feet in Leslie County, Kentucky. On the western side of the Cincinnati arch the group apparently attains its maximum thickness of 690 feet in Gallatin County, Illinois. This suggests that the deepest part of the Meramec basin coincided approximately with that of the Chester.

The St. Genevieve is the so-called prolific "McClosky sand" of Illinois, Kentucky, and Indiana. Several oil fields have been found near the wedge edge of the St. Louis limestone where it has been overlapped by the Pennsylvanian beds. The shallow "stray" gas sands of

Michigan are found in beds probably lower Meramec in age. The Mountain or Maxville limestone, which probably is correlative with the St. Genevieve of the western basin, produces some oil in eastern Ohio.

OSAGE GROUP

In central and western Illinois the Osage group consists of a basal red, calcareous shale overlain by gray, cherty, finely to coarsely crystalline limestones and dolomites. Toward the southeast the lower part grades into sandy shales in Indiana, Kentucky, and Tennessee. Southward from Ohio the conglomerates and sandy shales of the Osage become more calcareous and in eastern Tennessee the upper part of the group is cherty limestone. However, the lower part persists as greenish shale. In Michigan the Osage was initiated by a basal red shaly limestone which was succeeded by slightly sandy, gray shales overlain in turn by fine to very coarse-grained, micaceous sandstones. The maximum thickness occurs in Michigan and is probably about 1,500 feet, thinning to approximately 800 feet in Ohio and 235 feet in Leslie County, southern Kentucky.

West of the Cincinnati arch the Osage attains its maximum thickness in Union County, Illinois, where cuttings from the McKay Smith Hine No. 1, Sec. 21, T. 11 S., R. 2 W., showed that 1,040 feet of rocks of Osage age had been penetrated. South from this well, in McLean County, Kentucky, there are 850 feet and in Wayne County, Tennessee, only 300 feet of these rocks remain.

The Keener, Big Injun, and Squaw oil sands are found in the upper part and the Weir sand in the lower part of the Osage rocks in the Appalachian geosyncline. Osage rocks also produce oil in Illinois and northern Tennessee.

CHATTANOOGA AND OHIO SHALES

The Chattanooga is black or dark brown, fissile shale containing gray or light green streaks which increase both in number and thickness in a northerly direction. In southwestern Indiana and southeastern Illinois thin, gray, finely crystalline limestone lies at the top of the Chattanooga. This limestone, which is called Rockford, is remarkably persistent although only locally is it more than 5 feet thick. In a few places in Kentucky a limestone of similar lithologic character occurs near the base of the black shale. The Chattanooga is thickest in western Illinois where 250 feet are found, and from that locality it thins toward the southeast into eastern Alabama where its average thickness is only 20 feet.

The Ohio is predominantly black but has much more green or gray

shale interbedded with the black than in the Chattanooga of the western coal basin. Near the top of this shale is the oil-bearing Berea, which is shaly, fine to coarse-grained, angular, sandstone whose porosity varies greatly within short distances. In many places on both sides of the Cincinnati arch a thin pyritic sandstone is found at the base of the black shale where the normally underlying Devonian limestones have been eroded.

The typical Ohio section of black shale is found in eastern Michigan. The upper part of the Antrim grades westward into a sandy, greenish shale phase which is named Ellsworth. More than 800 feet of this Mississippian-Devonian shale is found in western Michigan. The maximum thickness of black shale known to the writer, in the area covered by this report, is 3,450 feet. This is present in a well in Washington County, southeastern Ohio. In eastern Kentucky there is approximately 1,000 feet but in the Blue Ridge Mountains of eastern Tennessee the greatest thickness is 500 feet.

The lower part of the Ohio shale is the black shale of the Appalachian geosyncline, and it is very probably Devonian in age. This shale produces gas in eastern Kentucky and small amounts in Ohio and northern Michigan.

MIDDLE DEVONIAN LIMESTONES

The Hamilton, which is the upper limestone of Devonian age, is brown or gray, crystalline to finely crystalline, slightly cherty limestone which in Ohio, Indiana, Kentucky, and Illinois contains a basal sandy phase, especially where the underlying limestones have been subjected to erosion. The limestone becomes more shaly toward the north and east and both the Hamilton and Onondaga in the Appalachian geosyncline are represented by dark, calcareous shales locally interbedded with a few thin limestones. In western Michigan there are three beds of anhydrite interbedded with brown, finely crystalline Hamilton dolomite. Locally in Kentucky, Indiana, Michigan, and Illinois thin beds of dolomite occur in the limestone, and, in a few places, glauconite and black phosphatic nodules. In northwestern Illinois the Devonian limestone, which is considered by Workman[4] as being slightly younger than the Hamilton, is white or light gray and, in the lower part, in many places contains thick beds of lithographic limestone. The Middle and Lower Devonian limestones are both present in southern Illinois, the whole section being composed of very cherty limestone or true novaculite. In Brown, Cass, Mason, Logan,

[4] L. E. Workman, "Subsurface Stratigraphy of the Devonian in Western Illinois," *Trans. Illinois Acad. Sci.*, Vol. 27, No. 2 (1934), pp. 123–24.

Menard, Macon, and parts of Adams, Pike, Scott, Morgan, Sangamon, Christian, Shelby, Moultrie, Pratt, DeWitt, Tazewell, Fulton, and Schuyler counties, Illinois, the Kinderhook shale rests on Niagaran limestones, all of the Devonian being absent.

The Onondaga, which is lower Middle Devonian, is light gray, dense to finely crystalline limestone. Locally in Indiana, Tennessee, and in Kentucky near Louisville the Onondaga is light gray, coarsely crystalline, pink-spotted limestone. This limestone is absent in northwestern Indiana and southwestern Michigan and in most of Kentucky, Illinois, and Tennessee.

Erosion which was initiated by the post-lower Helderberg, pre-Onondaga uplift of the Jessamine and Nashville domes, the Ozark Mountains, and the Kankakee and Cincinnati arches, caused the thickness of the Middle Devonian limestones to vary within short distances in the areas affected by these uplifts. The thickest sections known to the writer occur in the northeast-central part of the Michigan basin where approximately 1,100 feet of Hamilton-Onondaga beds have been penetrated. In Ohio the maximum thickness of Middle Devonian known to the writer is 170 feet; in Indiana, 75 feet; in Kentucky, 115 feet; in Tennessee, 19 feet; and in southern Illinois, 700 feet.

The Hamilton-Onondaga limestones produce in Barren, Boyd, Breckinridge, Carter, Estill, and Ohio counties, Kentucky. The Traverse and Dundee limestones of Michigan, the "Niagara" limestone of Clark, and the Hoing sand of McDonough County, Illinois, are other Middle Devonian producing strata. The Siosi and the new Prairie Creek pool opened by the Carter Oil Company in Vigo County, Indiana, probably produce from Middle Devonian beds.

LOWER DEVONIAN

The Oriskanian beds vary from the pure coarsely crystalline limestones of southwestern Illinois to the sandy finely crystalline limestones, dolomites, and anhydrites of Michigan and Ohio. In the eastern part of Ohio there are local developments of oil-bearing St. Peter-like sandstones which are called Austinburg. This sandstone possibly represents the Oriskany sandstone of the New York section.

The Oriskanian of western Tennessee contains a series of yellow or white novaculites, in places overlying thin dolomitic limestone.

The Oriskanian beds are probably absent in Indiana, eastern Tennessee, and the greater part of Illinois.

The lower Helderbergian of the Michigan basin contains a series of dolomite, anhydrite, salt, and basal sandstone or siliceous dolomite.

This is the only state in the area in which salt beds are found in the Lower Devonian. Beds of this age are absent in central and western Kentucky, eastern Tennessee, and in most of Ohio, Illinois, and Indiana.

The lower Helderbergian of western Tennessee contains gray, porous chert at the top, overlying a series of gray shales and thin-bedded limestones which become thicker in the lower part of the section. This shaly section overlies gray or red, coarsely crystalline limestone. The lowermost member of the lower Helderbergian group is greenish, calcareous shale which in places contains small amounts of limestone.

The lower Helderbergian of eastern Kentucky contains fine-grained sandstone lenses in the finely crystalline limestone or dolomite. These beds are entirely different from those found along the Tennessee River in the western part of the state.

So far as the writer knows there is no oil or gas production from the lower Helderbergian[5] in the area covered by the report.

SILURIAN

CAYUGA-SALINA GROUP

The Cayuga-Salina beds contain white to brown, finely crystalline, slightly granular and argillaceous dolomites interbedded with a variable amount of salt, anhydrite, or gypsum. Leached oölitic zones are commonly found in the Cayuga beds. Locally the dolomite is red and much more shaly than it is in the typical development. In the deeper parts of the Michigan basin three thick salt beds separated by dark gray, dense limestone or brown dolomite occur in these rocks.

At the base of the Cayugan of eastern Kentucky is a zone of milky quartz pebbles and coarse-grained, angular sandstone which is the erosional debris occupying the position normally held by the Niagara dolomite. This zone, which in places attains a thickness of 60 feet, is the Big Six gas horizon of eastern Kentucky and West Virginia.

The Decatur, which is the Cayuga in the western basin, is light gray, dense to coarsely crystalline, magnesian limestone which locally contains red streaks.

If the Cayugan sea covered the entire area of this report, later erosion has thinned or entirely removed these deposits from the crests of the Jessamine and Nashville domes and the Kankakee and Cincinnati arches.

The Salina sea probably did not extend into western Ohio, Indiana, Illinois, and western Kentucky. The remainder of the area contains variable thicknesses of these beds.

[5] The recent discovery in the Wisner pool, Tuscola County, Michigan, may be lower Helderbergian.

The Cayuga-Salina beds attain their maximum thickness of possibly 3,000 feet in the Michigan basin and thin toward the south for they are only 70 feet thick in western Tennessee and less than 475 feet thick in the eastern part of that state.

At least six fields in Kentucky are producing from Cayugan beds. To date this is the only state in the region where these beds have yielded commercial amounts of oil and gas. Several wells in Michigan, including the deep test on the Howell structure, have produced small amounts of gas from rock of Salina age.

NIAGARA DOLOMITE

In Michigan, Ohio, northern Illinois, eastern Indiana, and northeastern Kentucky the Niagara is light gray, crystalline, hackly, slightly mottled porous dolomite, containing minor amounts of finely crystalline beds in the lower part. In places these rocks contain thin beds of gray or brown chert. As a rule the dolomites become more argillaceous in the lower part where they grade into the underlying shaly Brassfield.

In southern Illinois, southwestern Indiana, western Kentucky, and western Tennessee the Niagara contains two phases: an upper phase of pure limestone and dolomite, and a lower shaly limestone or calcareous shale. The upper phase is a white to light gray, finely crystalline to coarsely crystalline, pink-spotted, slightly glauconitic limestone containing thin dolomitic streaks. Locally in northwestern Illinois thin St. Peter-like sandstones are found in this upper phase. The lower phase may be gray or red calcareous shale or dark gray, greenish, or red argillaceous limestone. The red color is common only in southern Illinois and western Kentucky.

In the Michigan basin and the western part of the Appalachian geosyncline there seems to be a compensating relationship between the Cayuga-Salina and the underlying Niagara. Farther east in Pennsylvania, Virginia, Maryland, and West Virginia the Niagaran beds are absent. Where the Cayuga-Salina is abnormally thick the Niagara is thinner than normal. These compensating variations in thickness are local as well as regional. This compensation may be due to a combination of several, or to any one, of the following four conditions: (1) coral reefs extending upward from the typical Niagara into the overlying beds; (2) Cayuga-Salina beds filling valleys on an old Guelph erosional surface; (3) unconformity at the base of the Cayuga-Salina beds with a conglomerate composed of Guelph pebbles; (4) conditions of sedimentation in lower Salina time, which were locally similar to those of Niagara time, making a gradational contact. There are prob-

ably areas where condition number one accounts for the lateral variation, for coral reefs are undoubtedly very common in the Niagaran rocks. The Niagara has been removed by erosion in eastern Kentucky near the state line. The debris that marks this unconformity is largely composed of sand and quartz pebbles, only a minor amount being Niagara dolomite pebbles. This leads one to discount number three. Number two is ruled out by the fact that except in the western Appalachian area there is no evidence of erosional debris between the Salina and Niagara; consequently, the writer does not feel that in most of the area valleys more than 100 feet deep were filled by deposits of the advancing Salina sea. After considering all these facts it seems most likely that the contact is gradational with conditions in lower Salina time locally being very similar to those of Niagara deposition.

The discovery gas field of Illinois located on the Pittsfield anticline of Pike County, produced from the Niagara dolomite. To date no other pool in that state has produced from the Silurian. However, in Kentucky numerous fields in eighteen counties produce from rocks of Niagara age. On account of the gradational contact between the Niagara and the overlying Cayuga-Salina beds it is very difficult to obtain representative thicknesses for each of them. The Niagara dolomite probably reaches its maximum thickness in the Michigan basin where 550 feet have been penetrated. Southward it thins into northern Kentucky where it is cut out by the overlap of the Cayugan dolomites.

The writer has learned recently from A. C. McFarlan at the University of Kentucky that he has found Niagaran fossils in cores from the producing horizons in several eastern Kentucky oil fields. This corroborates conclusions reached earlier by the writer after an extensive lithologic study of well cuttings. Heretofore the Kentucky production has been considered as coming from the Middle Devonian limestones.

BRASSFIELD BEDS

The Brassfield of Michigan, Ohio, eastern Kentucky, eastern Tennessee, and eastern Indiana is gray or red, fine-grained, calcareous shale overlying gray, finely crystalline to crystalline, gnarly, slightly cherty dolomite. In western Kentucky the lower Brassfield limestone which underlies the upper red or gray shale or shaly limestone is very similar lithologically to the upper part of the Niagara except that locally it may contain interbedded greenish shales. In the Appalachian geosyncline the Brassfield consists of green or maroon oölitic shale and several fine-grained, shaly sandstones. Toward the west the Brass-

field progressively grades from shale and sandstone to shale and limestone and finally to cherty, slightly glauconitic limestone or dolomite in the Illinois-Kentucky coal basin. This gradation of sand and shale to dolomite or limestone and shale also takes place toward the south.

The great Clinton gas field on the east flank of the Cincinnati arch produces from the updip wedge edge of the sands of Brassfield age.

The Brassfield thins from 400 feet in eastern Ohio to 45 feet in Jersey and Calhoun counties, Illinois. According to Savage[6] of the University of Illinois, it thickens southward from northern Illinois to Kentucky by addition of lower beds. Farther south it thins, for the maximum thickness recorded in publications of the Tennessee Geological Survey is only 25 feet for the western basin. This southward thinning does not seem to take place in the Appalachian geosyncline. The maximum thickness of 400 feet in Ohio agrees well with that in Tennessee where 400–500 feet of Brassfield beds are exposed.

ORDOVICIAN

CINCINNATI GROUP

The rocks of the Cincinnati group are primarily gray shales and thin, gray, interbedded, shaly limestones or dolomites. In the eastern part of the area the Richmond or upper Cincinnatian contains much dark red, fine-grained shale which grades laterally into gray shale in western Ohio and western Kentucky. Southward the amount of limestone in the section increases into northern Tennessee where the group consists primarily of limestone and dolomite with thin intercalated shale stringers.

According to Ulrich[7] the oldest Cincinnati sea covered only part of Michigan, Ohio, and northern Kentucky. The next, or Eden sea, covered a slightly greater area but its deposits were in turn overlapped by those of the Maysville sea. The last, or Richmond sea, was by far the most widespread as one can readily see by examining the correlation tables.

Production is obtained from the limestone or dolomites of the Cincinnati group in Kentucky and Tennessee and in one well in the Martinsville pool of Clark County, Illinois.

The Cincinnati group thickens eastward from a maximum of 290 feet in Illinois to approximately 1,100 feet in eastern Ohio. These rocks also thin slightly toward Kentucky and Tennessee and in the opposite direction toward northwestern Michigan. This thinning is probably due to loss of beds in the lower part of the group.

[6] T. E. Savage, "Silurian Rocks of Illinois," *Bull. Geol. Soc. America*, Vol. 37, No. 4 (1926), pp. 513–34.

[7] E. O. Ulrich, personal communication.

"TRENTON" LIMESTONE

In this article the true Trenton, Black River, and Stones River limestones of the southern area are included under the general term "Trenton." In parts of Michigan, Ohio, and Indiana, the upper part of the "Trenton" is amber, crystalline, porous dolomite which grades into limestone of similar lithologic character away from the major uplifts. The middle part of the "Trenton" is light gray or amber, finely crystalline to dense, hard limestone with local developments of chert. In Illinois at the top of the second phase there is gray shale or shaly limestone which contains gray, unweathered, brown-spotted chert. In Kentucky and Tennessee this horizon is marked by one or two thin, green, greasy, pyritic shales which contain much white and brown mica. These shaly beds mark the top of the Black River group. In Kentucky and Tennessee there is a lower dense, dark gray or brown, argillaceous phase which near the base apparently grades into the underlying Knox dolomite. This dark brown limestone is probably the Stones River which is overlapped by the Black River in a northerly direction. Although not completely cut out, the Black River thins in the same direction. Where the St. Peter underlies the "Trenton" there is a sandy dolomite and green shale phase resting on the true St. Peter sandstone. The "Trenton" beds have produced large amounts of oil and gas in Indiana and Ohio, and lesser amounts in Illinois, Kentucky, Tennessee, and Michigan.

The "Trenton" thickens from less than 600 feet in Illinois and Indiana to more than 1,100 feet in Tennessee. A large part of this southerly thickening is due to the addition of Stones River beds to the section.

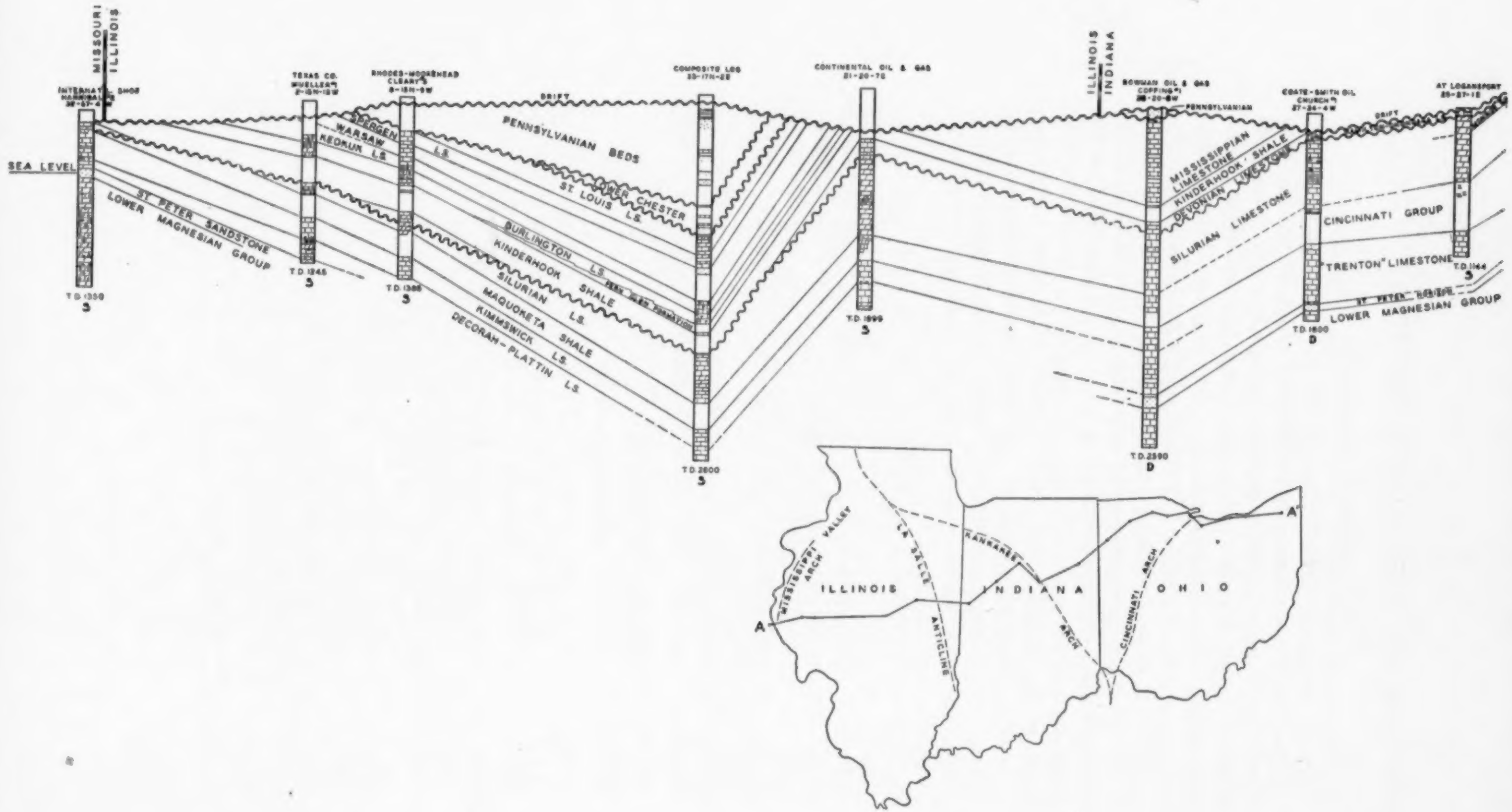
ST. PETER SANDSTONE

The St. Peter is white, rounded, frosted, coarse-grained sandstone with a few angular grains due to the deposition of secondary quartz. The basal part contains fragments of green shale and white-weathered chert which were derived from the erosion of the underlying beds. From the north where it overlies the Cambrian, the St. Peter successively overlaps younger beds in a southerly direction.

The greatest thickness of St. Peter sandstone known to the writer is 335 feet in McDonough County in western Illinois; in northwestern Indiana 150 feet is the maximum.

In Illinois, Iowa, Michigan, and Indiana the St. Peter underlies beds of Black River age. From deep wells in Kentucky Ulrich[8] reported calcareous sandstone, beneath at least three members of the

[8] E. O. Ulrich and N. H. Winchell, "Geology of Minnesota," *Minnesota Geol. and Nat. Hist. Survey*, Vol. III, Pt. 2, pp. xciii–xciv.



MISSOURI
ILLINOIS
SEA LEVEL
T.D. 1350
T.D. 1245
T.D. 1386
T.D. 2600
T.D. 1999
T.D. 2590
T.D. 1600
T.D. 1144
DRIFT
PENNSYLVANIAN BEDS
SPERGEN
WARSAW
KEOKUK LS.
LS.
LOWER CHESTER
ST. LOUIS LS.
BURLINGTON LS.
KINDERHOOK SHALE
SILURIAN LS.
MAQUOKETA SHALE
KIMMSWICK LS.
DECORAH-PLATTIN LS.
ST. PETER SANDSTONE
LOWER MAGNESIAN GROUP
COMPOSITE LOG
CONTINENTAL OIL & GAS
ILLINOIS
INDIANA
PENNSYLVANIAN
MISSISSIPPIAN LIMESTONE
KINDERHOOK SHALE
DEVONIAN LIMESTONE
SILURIAN LIMESTONE
CINCINNATI GROUP
"TRENTON" LIMESTONE
ST. PETER
LOWER MAGNESIAN GROUP
AT LOGANSPORT
MISSISSIPPI VALLEY ARCH
LA SALLE ANTICLINE
KANKAKEE ARCH
CINCINNATI ARCH
ILLINOIS
INDIANA
OHIO
A
A'

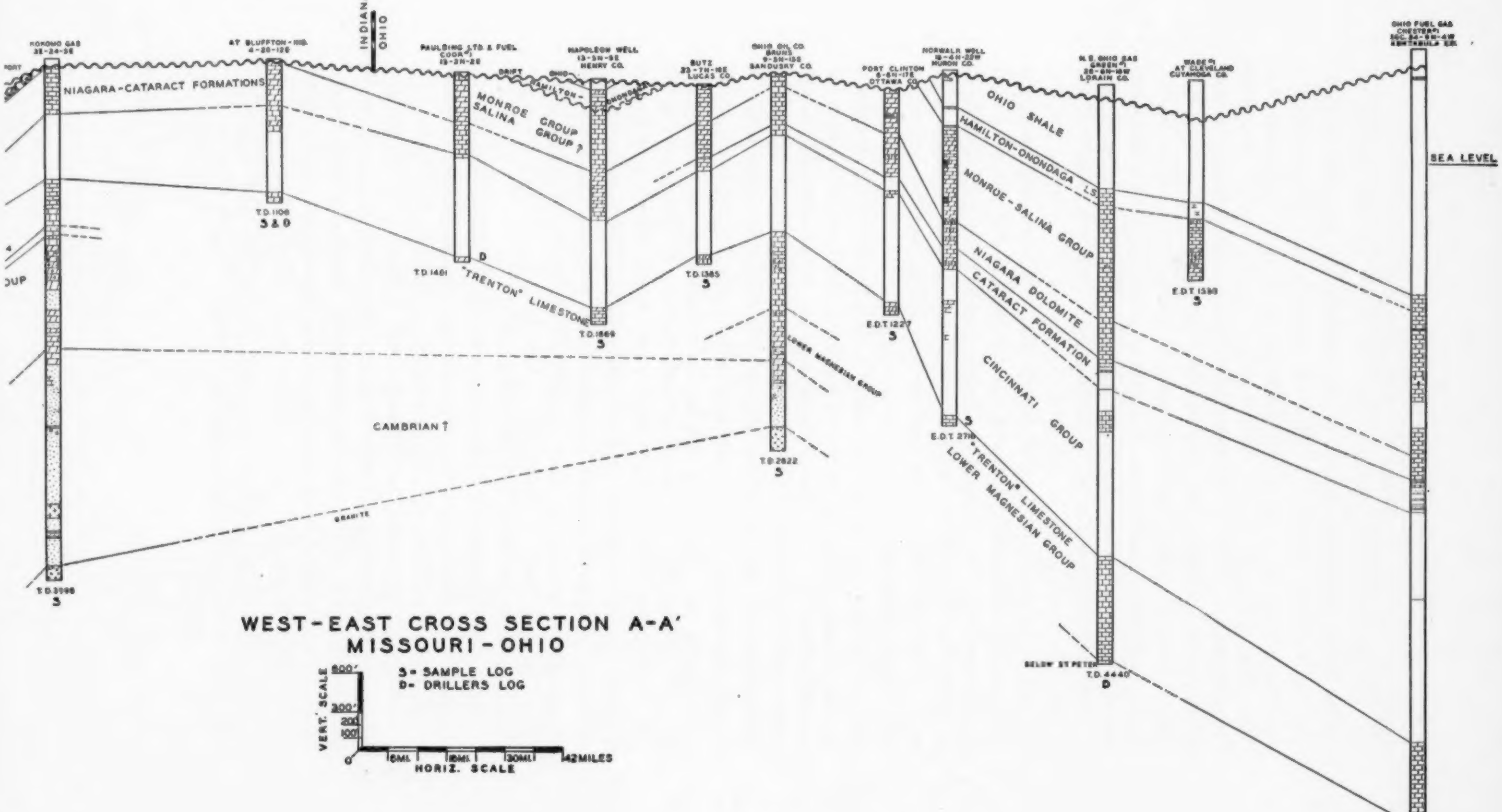

WEST-EAST CROSS SECTION A-A'
MISSOURI-OHIO
S- SAMPLE LOG
D- DRILLERS LOG
VERT. SCALE
HORIZ. SCALE
42 MILES
INDIANA
OHIO
SEA LEVEL
NIAGARA-CATARACT FORMATIONS
MONROE GROUP
SALINA GROUP ?
"TRENTON" LIMESTONE
CAMBRIAN ?
GRANITE
LOWER MAGNESIAN GROUP
OHIO SHALE
HAMILTON-ONONDAGA LS.
MONROE-SALINA GROUP
NIAGARA DOLOMITE
CATARACT FORMATION
CINCINNATI GROUP
"TRENTON" LIMESTONE
LOWER MAGNESIAN GROUP
BELOW ST PETER
AT BLUFFTON
PAULDING
NAPOLEON WELL
HENRY CO.
BUTZ
LUCAS CO.
OHIO OIL CO.
SANDUSKY CO.
PORT CLINTON
OTTAWA CO.
NORWALK WELL
HURON CO.
LORAIN CO.
AT CLEVELAND
CUYAHOGA CO.
OHIO FUEL GAS
T.D. 1106
T.D. 1401
T.D. 1869
T.D. 1365
T.D. 2822
E.D.T. 1227
E.D.T. 2719
T.D. 4440
E.D.T. 1530
T.D. 6004

Fig. 1

Stones River group. He correlated these sandstones with the St. Peter and consequently made it pre-Stones River in age. The writer has examined cuttings from all available deep wells in Kentucky and Tennessee and believes, as does Fanny Carter Edson,[9] that these sandstones are eastern representatives of several sandstones that occur in the Beekmantown outcrops in Arkansas and Missouri. Further in the subsurface, similar sandstones are found below the St. Peter in the Beekmantown in Michigan, Indiana, Illinois, Missouri, and Arkansas. Therefore, until proved incorrect, the writer prefers to consider the age of the St. Peter as pre-Black River instead of pre-Stones River.

As the St. Peter sandstone, which has been correlated with the "Wilcox" of Oklahoma, is traced in cross section *AA'* (Fig. 1) from the Coate-Smith Oil Company's Church No. 1, Sec. 27, T. 24 N., R. 4 W., to the Kokomo Gas and Fuel well, Sec. 32, T. 24 N., R. 5 E., there is a change from pure sand to thin sand streaks interbedded with sandy limestone. Samples from a well not shown on the cross section but which is east of the Kokomo well showed total absence of St. Peter sand. Since this eastward gradation from sand to limestone and dolomite has a distinct economic value a few remarks on the problem are not amiss. The interval from the top of the Galena or Kimmswick to the top of the unquestioned St. Peter sandstone is approximately 400 feet in northeast Missouri, northern Illinois, northern Indiana, and western Michigan. In Ottawa County, in the western part of Michigan, the interval from the top of the Trenton to the top of the lower Magnesian dolomite, which is here overlain by the St. Peter sand, is approximately 940 feet. In St. Clair County, north of Detroit, where there is no St. Peter sandstone, this Trenton-lower Magnesian interval is 965 feet. The constancy of this interval leads one to believe that the sandstone grades into limestone across the Michigan basin just as it does farther south.

In Illinois the interval from the top of the "Trenton" to the top of the first St. Peter-like sand increases from approximately 400 feet to more than 900 feet in a southerly direction. Whether this great increase in interval is due to addition of Black River beds not present farther north or is a simple lateral change is undeterminable at present. However, the writer believes that the St. Peter as a sandstone is probably absent in eastern Michigan, eastern Indiana, Ohio, Kentucky, and Tennessee.

[9] Fanny Carter Edson, "Résumé of St. Peter Stratigraphy," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 8 (August, 1935), pp. 1110–30.

PRE-ST. PETER BEDS

The upper part of the pre-St. Peter beds consists of light gray, finely crystalline to crystalline, sandy, cherty dolomite and minor amounts of thin, interbedded St. Peter-like sandstones. The amount of the sandstone varies locally but in a general way it seems to become more prominent toward the northwest. The middle part contains less sand than the upper part except in the northern part of the area where some of the Upper Cambrian sandstones are more than 200 feet thick. The lower phase contains much gray or red, fine to coarse-grained, glauconitic, micaceous sandstone with traces of gray or red variegated, fine-grained micaceous shale and pink or gray, crystalline, glauconitic, sandy dolomite. The basal Cambrian sandstone attains a thickness of approximately 2,500 feet in northern Illinois. These great thicknesses of sandstone show that the early sediments were derived from the erosion of the northern Archean shield.

The pre-Cambrian red clastic series, which contains quartz, pink feldspar, much biotite, mica, and red fine-grained shale, occurs below the Cambrian sandstones in the northern part of the area. Well cuttings from these beds are very similar lithologically to gneisses or schists.

The Friend Mattinson No. 1, located 11 miles southeast of Springfield, Ohio, deserves special mention since it is the only well examined that contains a metamorphosed pre-Cambrian section.[10] At 3,240 feet the well entered the arkosic sandstone that ordinarily overlies the basement granite. Below this basal Cambrian sand the drill penetrated more than 1,200 feet of dark gray or black, finely crystalline shaly dolomite and dolomitic shale possibly representing the Huronian slates of the Michigan Iron Range.

DISCUSSION OF CROSS SECTIONS

Cross section *AA'* is drawn along a line extending from eastern Missouri to Ashtabula County in northeastern Ohio. It shows the Cincinnati and Kankakee arches with the intervening southern end of the Michigan basin, and the steep dip into the structural and depositional basins of eastern Ohio and western Indiana. Out of the Marshall-Sidell syncline of western Indiana the strata rise to the crest of the asymmetric LaSalle anticline whence they plunge into the Western Interior coal basin, finally to rise toward the Ozark Mountains.

Although the reverse is true by the end of Trenton time, in pre-

[10] Isabel Wasson, "Sub-Trenton Formations in Ohio," *Jour. Geol.*, Vol. 40, No. 8 (1932), pp. 673–88.

Trenton time the Ohio arm of the arch was much higher than the Indiana arm. This is true because there is a greater thickness of pre-"Trenton" strata in Indiana than is present in Ohio, as found by a comparison of wells of similar structural position. After the deposition of the lower Magnesian group, the Kankakee or western arm rose more rapidly relative to the eastern arm for, irrespective of structure, the Upper Ordovician and Silurian beds are slightly thinner in Indiana than they are in Ohio.

Section *AA'* illustrates the eastward thickening of the Cincinnati group. This is probably due to thickening of individual members as well as to basal addition of the Maysville, Eden, and Utica beds which are absent in central Illinois. The eastward divergence of all formations from the Port Clinton, Ohio, well, on the east flank of the Cincinnati arch, is believed to be caused by thickening of individual members toward the axis of a depositional syncline and not due to appearance of new members in the stratigraphic column.

This cross section illustrates the steepening of dip with depth and three unconformities marked by the absence of beds in Illinois that are present elsewhere in the area under discussion. The oldest of these unconformities, which is post-Lower Devonian in age, was of such magnitude that locally the highest peaks were not covered until the basal Osage beds were deposited. In the water well No. 2 drilled at Hannibal, Missouri, by the International Shoe Company, Devonian limestone with a basal coarse-grained St. Peter-like sand overlies the Ordovician Kimmswick limestone, showing that at least 250 feet of section is absent. Northward tilting during the time represented by this unconformity brought about the condition shown in The Texas Company's Mueller No. 1, Sec. 2, T. 15 N., R. 13 W., where the Devonian limestone is absent. After a long period of erosion, during which all of the Silurian and Maquoketa beds on the northwest flank of the Ozarks were removed, this northward tilting occurred, thereby raising a previously low area in central-western Illinois too high to be covered by the southward encroaching Upper Devonian sea.

At the base of the Osage group in parts of western Illinois a formation of red and green glauconitic shale and shaly limestone is called the Fern Glen. The red color and presence of glauconite suggest at least a local shallowing of the seas. It is the writer's opinion that the Fern Glen is a gradational phase in the lower part of the Burlington and it is so shown in the cross section.

A composite log developed from the study of sets of samples from wells near Decatur, Sec. 33, T. 17 N., R. 2 E., shows that lower Chester beds rest unconformably on those of St. Louis age with the

St. Genevieve being absent. This condition is found in Christian, Macoupin, Montgomery, Macon, Fayette, St. Clair, and parts of Randolph and Monroe counties, Illinois.

The second major unconformity is at the base of the Pennsylvanian, which in the Rhodes *et al.*, Cleary No. 5, Sec. 8, T. 15 N., R. 9 W., Morgan County, Illinois, overlies Spergen limestone of Lower Mississippian age.

Section *BB'*, which is drawn from drillers' logs interspersed with a few obtained from cuttings, extends from Posey County in the extreme southwest corner of Indiana, across southern Ohio to Harrison County in the eastern part of the state. This cross section shows that the crest of the Cincinnati arch is very near the point where the Ohio-Indiana line intersects the Ohio River Valley. Near this point the axis bifurcates forming the two arms previously discussed.

The presence of salt in the eastern Ohio basin should be noticed. These salts grade updip into anhydrite and dolomite near the axis of the arch.

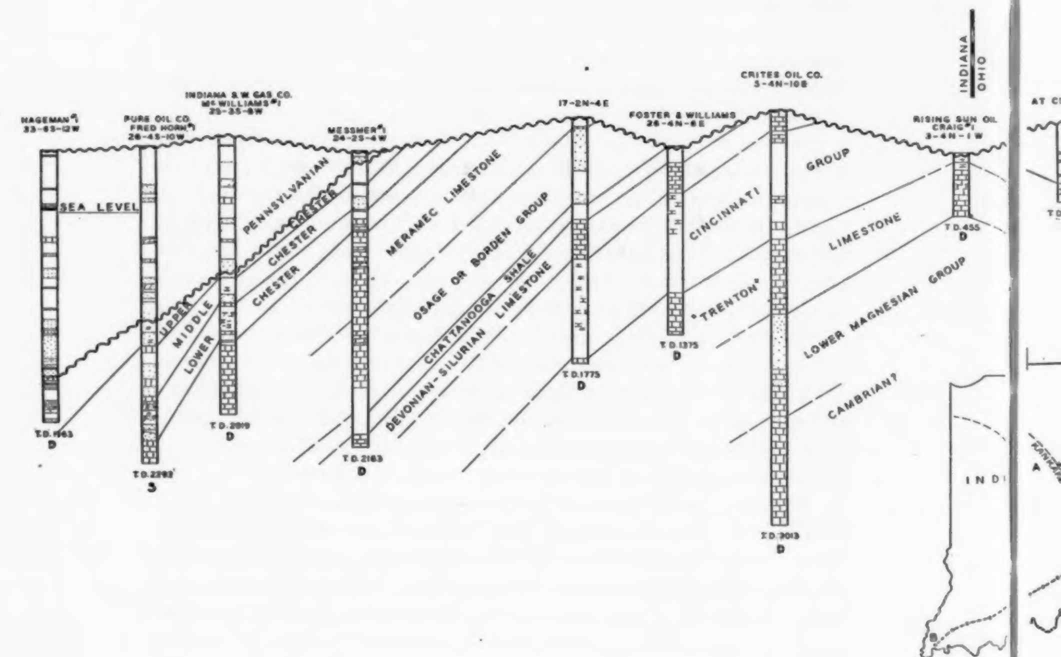
In the McCullough well in southeastern Ohio, the black Ohio shale probably rests on Hamilton limestone. Toward the Cincinnati arch the Ohio overlaps successively older beds and in outcrops in Adams County it is in contact with Niagara dolomite.

There is a great eastward thickening of the Ohio shale from a few hundred feet near the crest of the Cincinnati arm to approximately 2,700 feet in Harrison County. This thickening amounts to 25 feet per mile eastward; southeast and northwest it averages 40 feet per mile. Where these beds attain great thicknesses, interbedded remnants of the sands are found, which produce oil and gas in western Pennsylvania.

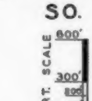
In comparing this section with *AA'* one notices the change from limestone to sands and shales in the lower part of the Osage. This change takes place in southerly and southeasterly directions in Indiana. This sandy phase crops out in Kentucky and forms the picturesque Knob country which has been made famous as the early home of Abraham Lincoln.

Cross section *CC'* extends from the granite outcrops of the Ozark Mountains to Mingo County, West Virginia. The west end is marked by the steep east dip as the Ozarks plunge into the Western Interior coal basin. From this basin the strata rise toward the crest of the Jessamine dome only to fall away into the Eastern coal basin.

Attention is called to the unconformity at the base of the Cayugan in the eastern basin. This unconformity is discussed in a summary of the folding of the whole region. This sandy conglomerate at the base of the Cayugan is known locally as the Big Six gas sand.



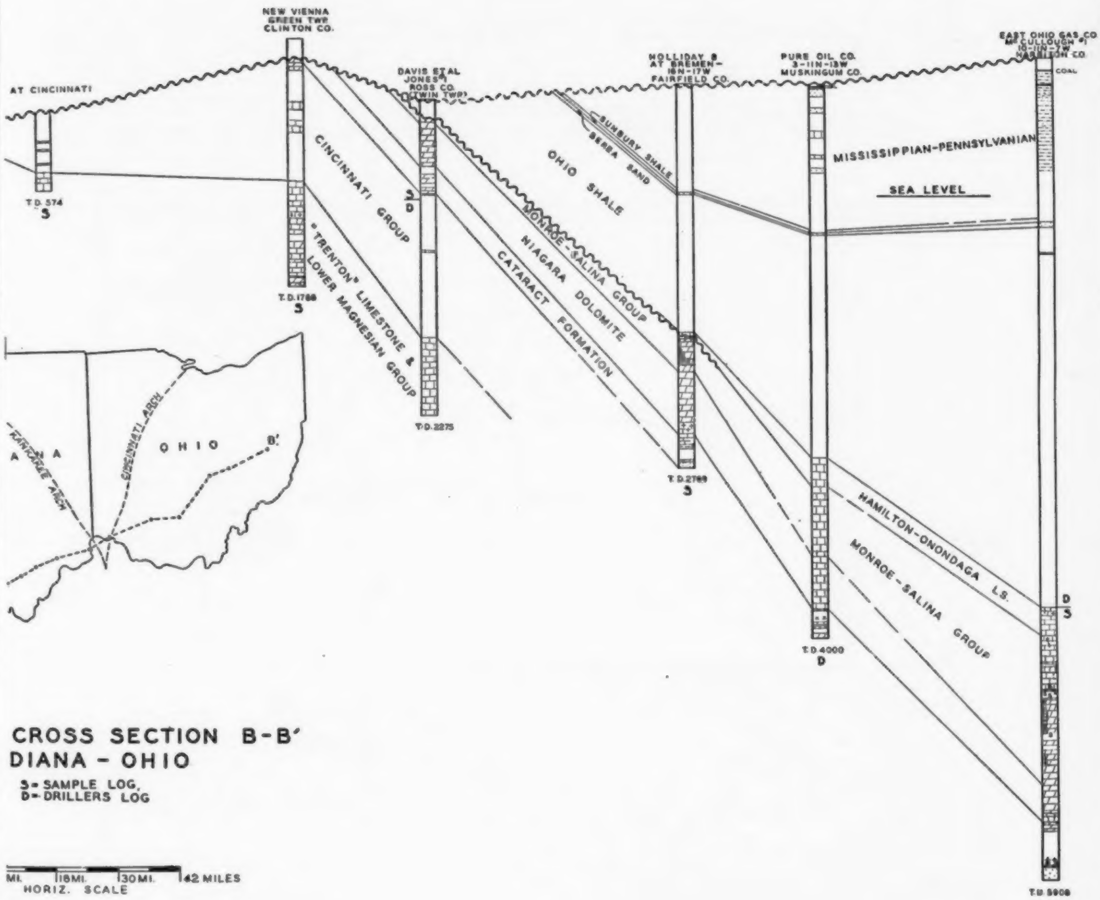
WEST-EAST
SO. IN



CR
DIA
S=
D=

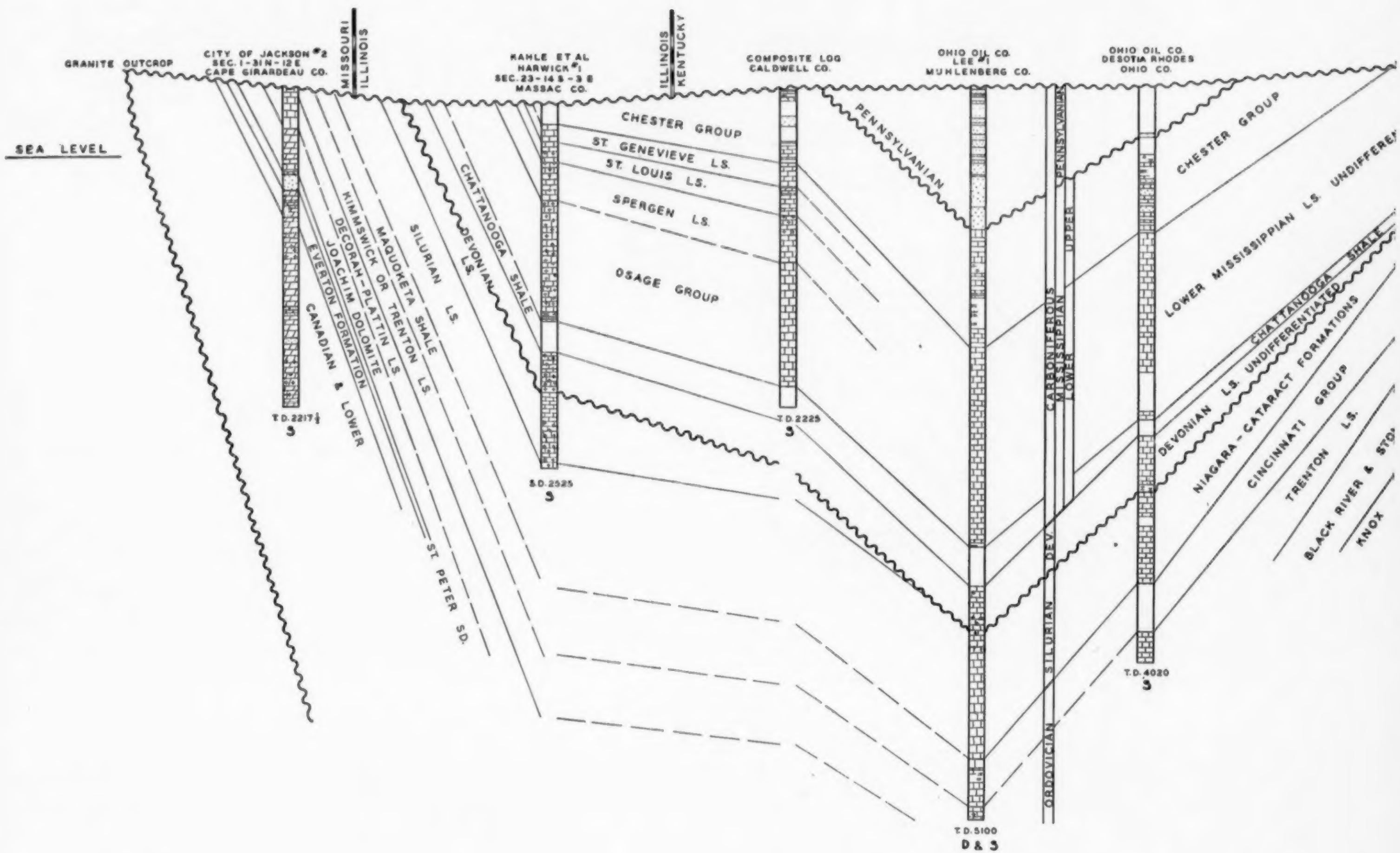
MI.
HO

FIG. 2



NEW VIENNA
GREEN TWP.
CLINTON CO.
DAVIS ET AL
JONES #1
ROSS CO.
(TWIN TWP.)
HOLLIDAY #
AT BREMEN-
16N-17W
FAIRFIELD CO.
PURE OIL CO.
3-11N-13W
MUSKINGUM CO.
EAST OHIO GAS CO
McCULLOUGH #1
10-11N-7W
COAL
AT CINCINNATI
T.D. 574
S
T.D. 1788
S
S
D
T.D. 2275
T.D. 2769
S
T.D. 4000
D
D
S
T.D. 5908
CINCINNATI GROUP
"TRENTON" LIMESTONE &
LOWER MAGNESIAN GROUP
MONROE-SALINA GROUP
NIAGARA DOLOMITE
CATARACT FORMATION
OHIO SHALE
SUNBURY SHALE
BEREA SAND
MISSISSIPPIAN-PENNSYLVANIAN
SEA LEVEL
HAMILTON-ONONDAGA LS.
MONROE-SALINA GROUP
OHIO
B'
CINCINNATI ARCH
KANKAKEE ARCH
A
CROSS SECTION B-B'
DIANA - OHIO
S= SAMPLE LOG,
D= DRILLERS LOG
MI. 18MI. 30MI. 42 MILES
HORIZ. SCALE

FIG. 2.



GRANITE OUTCROP
SEA LEVEL
CITY OF JACKSON #2
SEC. 1-31N-12E
CAPE GIRARDEAU CO.
MISSOURI
ILLINOIS
KAHLE ET AL
HARWICK #1
SEC. 23-14S-3E
MASSAC CO.
ILLINOIS
KENTUCKY
COMPOSITE LOG
CALDWELL CO.
OHIO OIL CO.
LEE #1
MUHLENBERG CO.
OHIO OIL CO.
DESOTIA RHODES
OHIO CO.
CHESTER GROUP
ST. GENEVIEVE LS.
ST. LOUIS LS.
SPERGEN LS.
OSAGE GROUP
CHATTANOOGA SHALE
DEVONIAN LS.
SILURIAN LS.
MAQUOKETA SHALE
KIMMSWICK OR TRENTON LS.
DECORAH-PLATTIN LS.
JOACHIM DOLOMITE
EVERTON FORMATION
CANADIAN & LOWER
ST. PETER SD.
PENNSYLVANIAN
LOWER MISSISSIPPIAN LS. UNDIFFEREN
CHATTANOOGA SHALE
DEVONIAN LS. UNDIFFERENTIATED
NIAGARA-CATARACT FORMATIONS
CINCINNATI GROUP
TRENTON LS.
BLACK RIVER & STO
KNOX
CARBONIFEROUS
PENNSYLVANIAN
MISSISSIPPIAN
UPPER
LOWER
DEV
SILURIAN
ORDOVICIAN
T.D. 2217½
S
S.D. 2525
S
T.D. 2225
S
T.D. 5100
D & S
T.D. 4020
S

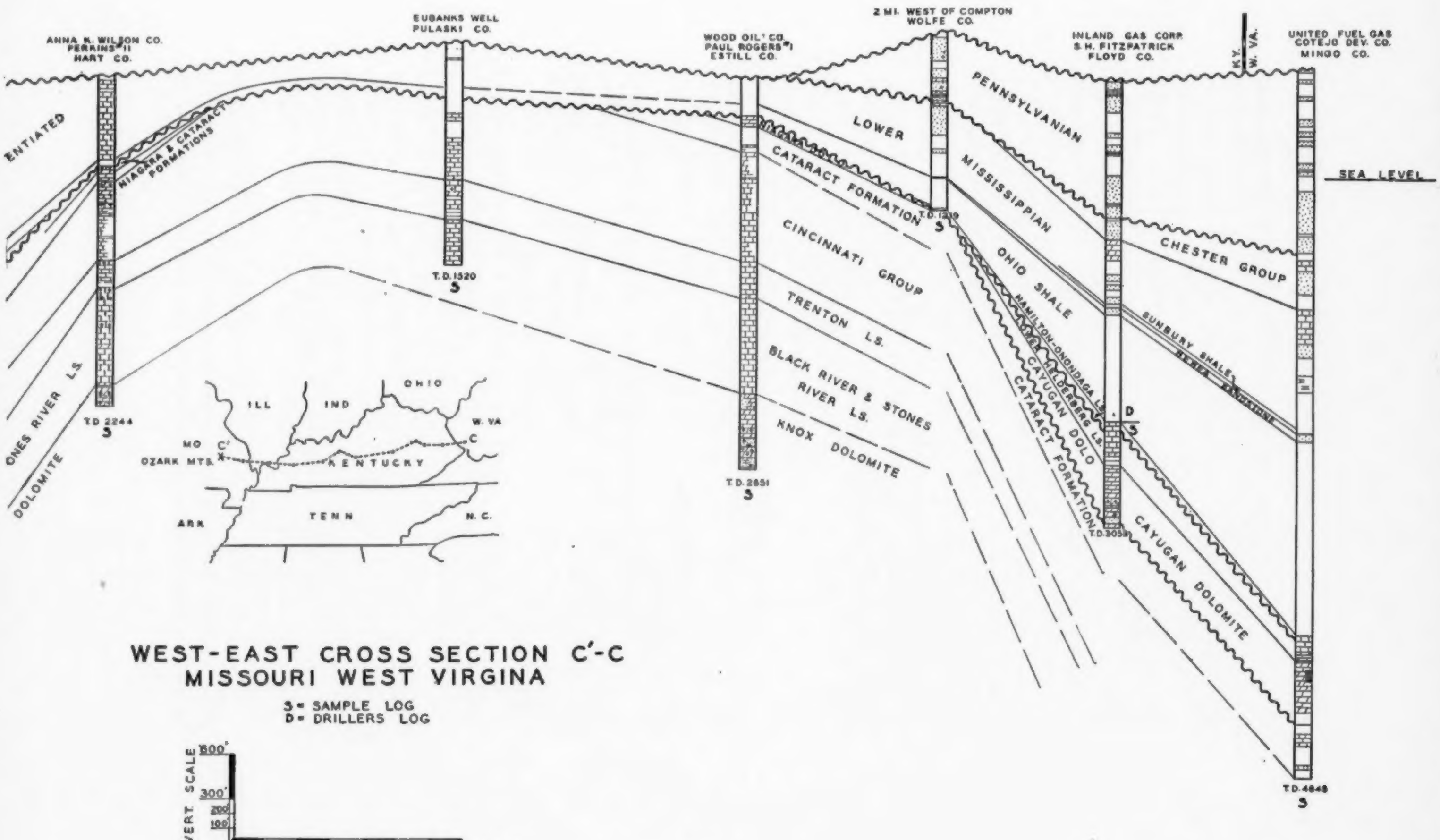

WEST-EAST CROSS SECTION C'-C
MISSOURI WEST VIRGINA
S= SAMPLE LOG
D= DRILLERS LOG
ANNA R. WILSON CO.
PERKINS #1
HART CO.
EUBANKS WELL
PULASKI CO.
WOOD OIL CO.
PAUL ROGERS #1
ESTILL CO.
2 MI. WEST OF COMPTON
WOLFE CO.
INLAND GAS CORP.
S.H. FITZPATRICK
FLOYD CO.
UNITED FUEL GAS
COTEJO DEV. CO.
MINGO CO.
KY.
W. VA.
SEA LEVEL
T.D. 2244
T.D. 1520
T.D. 2651
T.D. 3058
T.D. 4848
PENNSYLVANIAN
LOWER
MISSISSIPPIAN
CHESTER GROUP
OHIO SHALE
SUNBURY SHALE
HAMILTON-ONONDAGA LS.
HELDERBERG LS.
CAYUGAN DOLO
CAYUGAN DOLOMITE
CATARACT FORMATION
NIAGARA & CATARACT FORMATIONS
CINCINNATI GROUP
TRENTON LS.
BLACK RIVER & STONES RIVER LS.
KNOX DOLOMITE
ENTIATED
ONES RIVER LS.
DOLOMITE
ILL
IND
OHIO
W. VA
MO
OZARK MTS.
KENTUCKY
TENN
ARK
N. C.
VERT. SCALE
800'
300'
200
100
0
6MI.
18MI.
30MI.
42 MILES
HORIZ SCALE

FIG. 3

One must go far down the flanks of the Cincinnati arch before the Cayuga and lower Helderberg beds enter the section. However, from the point where they do enter, they thicken within short distances.

The log of the Ohio Oil Company's Lee No. 1 in Muhlenberg County, Kentucky, is very interesting on account of the abnormally thick Silurian that was drilled. At this point and in other wells in western Kentucky there is much more red, argillaceous dolomite and red shale than is found at any other place in the area under discussion.

The post-Lower Devonian unconformity is also well developed in the area shown in this section for Hamilton-Onondaga limestone is in contact with Niagara dolomite on the flanks of the Jessamine dome. Near the crest of that uplift the Chattanooga shale is in contact with beds in the Cincinnati group, the former having overlapped even the Hamilton-Onondaga limestone.

The Pennsylvanian thickens into the coal basins and rests on successively younger Mississippian beds both toward the east and west from the Jessamine axis.

Periods of Uplift

The Archean shield on the north, Appalachia on the east, the Ozarks on the west, and the converging Cincinnati and Kankakee arches which culminate in the Jessamine and Nashville domes are the major features that influence the structural history of the area covered in this article.

The first folding that affected this area occurred near the end of the Proterozoic in south-central Wisconsin. At that time the Baraboo quartzite was folded into the steep east-west trending anticline known as the Baraboo uplift. The first sea completely to cover that uplift was the Franconia of middle Upper Cambrian age.

The next period of folding also affected only the northern part of the region. In Boone County, Illinois, St. Peter sandstone rests on Upper Cambrian strata. Southward from Boone County the St. Peter rests on beds successively younger. In Tennessee, pre-St. Peter-Stones River beds, which apparently were not deposited farther north than southern Indiana, appear in the section. Black River beds, which overlie the Stones River, and overlap it, extend over the whole region but are much thicker in the south than in the northern part of the region. All of this evidence indicates a gradual tilting toward the south in pre-St. Peter time.

The Appalachian Mountains were first folded from southern New York to Alabama after the deposition of the Cataract or Brassfield and before the deposition of the Cayuga. This took place immediately

after the deposition of the Niagara dolomite for pebbles of it are included in the basal Cayuga conglomerate of eastern Kentucky as shown in cross section *CC'*. No wells have been drilled in eastern Ohio deep enough to reach this conglomerate, but the Niagara must feather out eastward as it is absent on the outcrops in Pennsylvania.

The Cincinnati and Kankakee arches and the Nashville and Jessamine domes were all being slightly warped during Ordovician and Silurian time, but it was not until the beginning of Onondaga time that folding of major importance took place. This folding probably reached the maximum about the end of Hamilton deposition for on the flanks of the Ozarks there was much post-Hamilton faulting.[11] Near the arch in southwestern Michigan, northwestern Indiana, and northeastern Illinois, Hamilton or Onondaga limestones rest on successively older beds. In Ohio the Onondaga overlaps beds as old as Upper Silurian. Still farther south both the Onondaga and Hamilton are absent and, according to Bassler,[12] Chattanooga shale lies on Clinton in a well in Pike County, southern Ohio. Since Pike County is farther down the flank of the arch than many surface occurrences where Chattanooga shale rests on Niagara dolomite, Bassler's interpretation may be open to question, unless the eastward thinning of the Niagara has cut out the formation within a short distance east of its present outcrop. Until more deep wells have been drilled in the area it is impossible to determine which explanation is correct.

In Jefferson and Oldham counties, Kentucky, the Onondaga rests on Niagara. Farther north in Indiana it lies on Cayuga beds. Everywhere on the flanks of the Jessamine dome, except in these two counties, either Chattanooga shale or Hamilton limestone overlaps the Ordovician. With the possible exception of some basal black shales deposited in the Appalachian geosyncline, so far as known no Hamilton beds were ever deposited in Tennessee. Four small scattered outcrops of Onondaga indicate an overlap by that formation, but except in these four areas Chattanooga shale is the overlapping formation everywhere on the Nashville dome.

Near the Ozark Mountains in Illinois, and in western Michigan there was pre-Osage warping, although there does not seem to have been any major folding at that time. Basal Osage beds in these two areas contain red, calcareous shales and red or pink argillaceous limestones. Furthermore, in several counties in central-western Michigan,

[11] Stuart Weller, "Geology of St. Genevieve County, Missouri," *Missouri Bur. Geol. and Mines*, Vol. 22, 2d Ser. (1928), p. 299.

[12] R. S. Bassler, "Deep Well at Waverly, Ohio," *Amer. Jour. Sci.*, Vol. 31, Ser. 4 (1911), pp. 19–24.

rounded sand grains are found in this zone.[13] Locally in southwestern Illinois all the beds equivalent to the Chattanooga shale were removed before the deposition of the red basal Osage beds.

At the end of St. Genevieve deposition local uplift in Illinois caused the removal of the St. Genevieve limestone in parts of Macon, Christian, Macoupin, Montgomery, Fayette, St. Clair, Monroe, and Randolph counties.

The second period of major folding to affect the area occurred at the end of Mississippian time. When the Pennsylvanian sea advanced over the old land surface at least several hundred feet of beds had been removed, for Pennsylvanian overlaps St. Peter sand in northern Illinois.

The last uplift to affect the area occurred after the deposition of the Pennsylvanian and before the Cretaceous beds were laid down, for faults in Kentucky displace Pennsylvanian but do not cut Cretaceous. T. E. Weirich[14] says that the gentle folds in the post-Pennsylvanian beds are probably due to subsidence of the Mississippi embayment.

Summary of Uplift

Major Folding

1. Post-lower Helderberg, pre-Onondaga
2. Post-Mississippian, pre-Pennsylvanian

Minor Folding

1. Pre-Cambrian
2. Post-Canadian, pre-St. Peter
3. Post-St. Peter, pre-Joachim
4. Post-Brassfield, pre-Cayugan
5. Post-Chattanooga, pre-Osage
6. Post-St. Genevieve, pre-Chester
7. Post-Pennsylvanian, probably post-Permian

Well Logs

The following logs which have been made from the studies of cuttings give more details of the stratigraphy than it is possible to give in the discussion. In these logs the limestones and dolomites are finely crystalline unless otherwise noted.

Michigan Petroleum Company's Moe No. 1, Ottawa County, Michigan

SE., SW., SE., Sec. 6, T. 9 N., R. 13 W.
Elevation, 704 feet
Total depth, 6,310 feet

Depth in Feet

251 Glacial drift

[13] After this paper was prepared, C. C. Addison in a personal communication says that in Allegan County, Michigan, there is possibly some evidence that strata between the base of the Osage and the base of the Mississippian thin over the tops of the oil-producing structures.

[14] T. E. Weirich, personal communication.

Depth in Feet	
	MICHIGAN FORMATION
255	Gray shaly dolomite
265	Light gray fine-grained micaceous shale
270	White anhydrite
370	No samples
400	Red coarse-grained angular poorly cemented sand
455	Red very coarse-grained angular micaceous sand
470	Gray to red well cemented angular micaceous sand
473	Brown slightly granular dolomite
	NAPOLEON SAND
543	Red, gray, and green coarse- to very coarse-grained sand
	LOWER MARSHALL FORMATION
630	Gray-red medium- to fine-grained shaly micaceous sand
	COLDWATER SHALE
885	Gray fine-grained micaceous shale
905	Gray-brown glauconitic dolomite
1,280	Gray fine-grained micaceous shale
1,290	Red shaly limestone and calcareous shale
1,300	Gray-red finely crystalline to crystalline dolomite
	ELLSWORTH-ANTRIM SHALE
1,300	Greenish to dark gray micaceous shale, contains a few large *Sporangites huronense*
1,400	Above shale and gray hackly dolomite
1,555	Greenish gray micaceous shale, trace of above dolomite
1,610	Gray gritty dolomite, 75 per cent; above shale, 25 per cent
1,750	Greenish gray fine-grained micaceous shale with thin streaks of brown bituminous shale
1,995	Browner shale and many large spores
2,008	Brown limestone and brown shale
	TRAVERSE FORMATION
2,025	Gray shale with streaks of light gray finely crystalline limestone
2,045	Gray shaly limestone
2,050	Gray shale
2,057	Light brown coarsely crystalline dolomite
2,140	Brown limestone with coralline streaks
2,150	Above limestone and white fresh and weathered mottled chert
2,160	Light gray-amber limestone
2,190	Dark gray shaly limestone
2,210	Finely crystalline to dense coralline gray limestone
2,225	Light gray limestone
2,230	Gray hard dolomite and anhydrite
2,235	Light gray limestone
2,240	Gray crystalline sucrose dolomite
2,252	Gray slightly weathered chert in brown shaly limestone
2,260	Brown granular dolomite
2,370	Light gray coralline limestone
2,395	Gray and brown sucrose dolomite with white weathered to fresh opalescent chert
2,405	Gray fine-grained micaceous shale
	DUNDEE LIMESTONE
2,465	Light gray to brown non-fossiliferous limestone
	DETROIT RIVER FORMATION
2,473	Gray-brown granular dolomite
2,485	White anhydrite
2,540	Brown granular dolomite
2,610	Anhydrite with several thin dolomite layers
2,630	Light buff slightly granular dolomite

Depth in Feet	
2,675	Anhydrite
2,695	Light buff slightly granular dolomite
2,700	Anhydrite
2,715	Amber dolomite
2,795	Anhydrite
	SYLVANIA SANDSTONE
2,925	Anhydrite and dolomite with included rounded frosted coarse sand grains
2,935	Gray fresh chert in brown dolomite
	BASS ISLAND FORMATION
2,990	Light gray dolomite
3,180	Gray and dark gray shaly dolomite
3,300	Light gray dolomite
3,355	Light gray dolomite with anhydrite streaks
	SALINA FORMATION
3,495	Salt
3,505	Brown dolomite and anhydrite
3,540	Dark gray dense limestone
3,550	Brown sucrose dolomite
3,618	Gray and dark gray dense limestone
3,630	Dark gray shaly dolomite; trace of anhydrite
3,655	Dark gray dense limestone
3,960	Salt
3,970	Anhydrite and brown slightly shaly dolomite
4,028	Brown sucrose dolomite
4,275	Salt
4,295	Brown dolomite and anhydrite
	NIAGARA DOLOMITE
4,310	Light gray pink spotted dolomite
4,360	Light gray finely crystalline to crystalline dolomite
4,415	Light gray limestone; cherty, 4,400–15 feet
4,450	Gray-brown dolomite and gray-brown fresh chert
4,522	Gray finely crystalline to dense limestone with thin streaks of greenish shale; bryozoan and crinoid stems
	CATARACT FORMATION
4,593	Thin limestone streaks in greenish shale
4,600	Light gray coarsely crystalline dolomite
4,630	Light gray mottled coarsely crystalline limestone; trace shale
4,680	Gray-brown dense limestone; shaly near base
	CINCINNATI GROUP
4,715	Light green to gray shale and limestone
4,735	Light green shale
4,785	Mostly gray crystalline limestone
5,048	Gray fine-grained shale, darker at base
	TRENTON LIMESTONE
5,065	Light brownish dolomitic limestone
5,090	Brown coarsely crystalline dolomite
5,110	Brown crystalline dolomite
5,240	Light gray to amber limestone
5,260	Light gray to amber limestone and brown fresh chert
5,305	Gray to dark gray limestone with argillaceous streaks
	BLACK RIVER (?) BEDS
5,445	Light gray finely crystalline to dense limestone
5,450	Above limestone and some coarse rounded porous sand
5,470	Amber dense limestone
5,480	Gray porous rounded frosted coarse-grained sand
5,490	Brown crystalline dolomite

Depth in Feet

ST. PETER SANDSTONE

5,650 Gray porous coarse frosted rounded sand

LOWER ORDOVICIAN

5,770 Light green shale and gray dolomite streaks
5,795 Red and green shale
5,840 Sand with thin streaks of gray dolomite
5,875 Rounded frosted well cemented calcareous sand
5,950 Sand with thin streaks of dolomite
5,975 Gray coarse frosted well cemented rounded sand

LOWER MAGNESIAN GROUP

5,990 Light gray sandy dolomite
6,005 Same with white oölitic chert
6,025 Above sand
6,055 Light gray sandy dolomite
6,085 Light gray dolomite
6,095 White angular medium-sized well cemented sand
6,180 Light to dark gray sandy dolomite
6,200 White fresh and weathered chert and light gray crystalline dolomite
6,250 Above dolomite and white weathered chert
6,310 Light gray finely crystalline to crystalline dolomite
Total depth

BUTZ NO. 1, LUCAS COUNTY, OHIO
SW. corner, Sec. 28, T. 7 N., R. 10 E.
Elevation, 620 feet
Total depth, 1,385 feet

Depth in Feet

35 Glacial drift

BASS ISLAND-SALINA FORMATIONS

45 Dark gray shaly dolomite
55 Light green shale
130 Light gray to buff dolomite
140 Dark gray shaly dolomite
180 Gray-brown slightly granular
223 Gray shaly dolomite

NIAGARA DOLOMITE

430 Light gray mottled crystalline dolomite
490 Light gray coarsely crystalline to crystalline mottled dolomite
495 Light green fine-grained shale
580 Light gray coarsely crystalline mottled dolomite

CATARACT FORMATION

677 Gray crystalline granular shaly dolomite and green fine-grained shale

CINCINNATI GROUP

710 Dark red to green shale
795 Gray to greenish shale
810 Gray coarsely crystalline dolomite
895 Dark red to green shale
910 Gray crystalline mottled dolomite
1,010 Greenish gray micaceous shale
1,100 Above and crystalline dolomite streaks
1,150 Above shale
1,200 Green-brown micaceous shale
1,332 Dark gray to brown micaceous shale

TRENTON LIMESTONE

1,355 Brown coarsely crystalline dolomite
1,380 Above with increased amounts of light gray crystalline to finely crystalline limestone
1,385 Limestone as above
Total depth
Showings of oil and gas at 485, 510, 570, 1,365 feet; no water reported

Ohio Oil Company's Bruns No. 1, Sandusky County, Ohio
NW., NW., SW., Sec. 9, T. 5 N., R. 13 E.
Elevation, 655 feet
Total depth, 2,828 feet

Depth in Feet	
1,170	No samples
12	Glacial drift
110	Limestone, Salina (?)
125	Shale
358	White limestone, Niagara (?)
368	Sand, Cataract (?)
435	Limestone
505	Red shale, Cincinnati group (?)
615	Gray shale
650	Limestone
730	Broken limestone
1,170	Shale, gray
1,177	Dark gray micaceous shale

"TRENTON" LIMESTONE

1,222	Light brown coarsely crystalline dolomite
1,285	Light gray-brown limestone
1,400	Dark gray shaly limestone; brown chert at 1,295–1,305
1,430	Light gray finely crystalline to crystalline limestone with gray to opal fresh chert
1,445	Above limestone, no chert
1,465	Dark brown fresh chert and shaly gray limestone
1,485	Light buff dense limestone (Black River?)
1,500	Same, light gray fresh chert
1,525	Same
1,550	Gray shaly finely crystalline to dense limestone
1,695	Light gray finely crystalline to dense limestone
1,705	Above with white fresh chert fragments
1,770	Above limestone
1,820	Light gray slightly granular dolomitic limestone
1,83c	Above and white to gray fresh chert; top Lower Ordovician (?)
1,835	Non-cherty
1,840	Rounded coarse frosted calcareous sand
1,875	Gray finely crystalline to dense
1,925	Above limestone and brown granular dolomite fragments
1,940	Brown dense limestone
1,975	Amber crystalline dolomite
1,985	Same and trace green dolomitic shale
2,000	Amber crystalline sandy dolomite
2,025	White crystalline slightly sucrose dolomite
2,055	White crystalline slightly sucrose sandy dolomite
2,075	White very coarse-grained rounded frosted calcareous sandstone
2,105	Non-calcareous sand
2,132	Calcareous sand as above
2,155	Light gray sucrose sandy dolomite
2,168	White medium- to coarse-grained porous rounded to angular sand

CAMBRIAN (?)

2,180	Gray sucrose glauconitic sandy dolomite
2,230	Gray sucrose glauconitic dolomite
2,305	Gray sucrose crystalline sandy dolomite
2,332	White coarse-grained rounded frosted sand
2,357	Gray finely crystalline to crystalline sandy dark spotted dolomite
2,490	Gray glauconitic sand
2,672	Gray to pink arkosic fine to coarse sand
2,828 Total depth	Pink feldspar, quartz, and mica

WALMER OIL COMPANY'S MILLER NO. 1, HANCOCK COUNTY, ILLINOIS
NW., SW., SW., Sec. 8, T. 3 N., R. 8 W.
Elevation, 731 feet
Total depth, 1,371 feet

Depth in Feet	
185	Glacial drift
	KEOKUK LIMESTONE
197	Gray fine-grained micaceous shale
210	Light gray mottled limestone and light gray fresh brown spotted chert; crinoid stems and bryozoans
215	Gray fine-grained micaceous shale
253	Similar to limestone and chert at 197 feet
260	Gray granular dolomite, 70 per cent; limestone, 30 per cent
275	Dolomite, 40 per cent; limestone, 60 per cent; all cherty
280	Dolomite, 80 per cent; limestone, 20 per cent; all cherty
300	Light gray soft mottled limestone and gray mottled fresh chert
325	White coarsely crystalline limestone; many crinoid stems
340	White granular crystalline dolomite; white to opalescent fresh chert
360	Light gray cherty finely crystalline to crystalline gnarly limestone
	BURLINGTON LIMESTONE
370	Light gray slightly granular glauconitic limestone; light gray to opal fresh chert
389	Limestone not glauconitic; chert as above
410	Gray fine-sized well cemented to porous angular slightly micaceous sandstone
420	White soft to amber crystalline limestone
448	Gray to amber crystalline granular dolomite
451	White soft limestone
482	Gray fine-grained, porous, slightly micaceous, angular sand calcareous at base
	KINDERHOOK SHALE
540	Light to gray micaceous shale
560	Light gray micaceous brown mottled shale
585	Gray and brown micaceous shale; *Sporangites huronense*
610	Greenish gray micaceous fine-grained shale
674	Gray micaceous fine-grained shale; brown at base; *Sporangites*
675	Gray coarse-grained well cemented rounded frosted sand
	DEVONIAN-CEDAR VALLEY LIMESTONE
690	Buff finely crystalline to crystalline dolomitic limestone
700	Same with rounded sand inclusions and trace of light gray fresh to weathered chert
730	Light gray mottled slightly granular limestone
745	White opalescent fresh chert; light gray soft limestone
750	White weathered to fresh chert and light gray to amber dolomitic granular limestone
761	Brown finely crystalline to crystalline sandy cherty sucrose dolomite
	DEVONIAN WAPSIPINICON LIMESTONE
778	Light gray finely crystalline to dense limestone
786	Light green pyritic shale and above limestone
	WEATHERED ZONE
796	Dark red shale representing time interval normally occupied by Silurian formations and Maquoketa shale
	GALENA DOLOMITE
815	Light gray soft finely crystalline limestone
820	White crystalline dolomite
840	Light brown crystalline dolomite
895	White soft finely crystalline limestone

Depth in Feet	
905	Light brown crystalline limestone and light gray fresh chert
910	Light brown crystalline limestone
949	Light gray to brown crystalline dolomite
980	Amber crystalline limestone containing rounded frosted sand grains and white weathered dolomitic chert
1,000	Gray finely crystalline brown spotted limestone
1,010	Light gray sucrose dolomitic limestone
1,026	Brown crystalline dolomite

ST. PETER SANDSTONE

1.070	Gray rounded frosted porous coarse-grained sand with some secondary growth of grains
1,105	Sand rounded to angular
1,160	Rounded and coarser at base

LOWER MAGNESIAN GROUP

1,170	Light gray dolomite
1,190	Light gray dolomite; white to gray fresh to weathered chert
1,205	Light gray to amber slightly granular dolomite with light gray to white fresh chert
1,225	Same dolomite with oölitic chert
1,239	White fresh to weathered chert; light gray dolomite
1,245	Rounded coarse frosted sand, 35 per cent; dolomite, 65 per cent
1,250	Light gray cherty dolomite
1,275	White fresh to weathered chert in light gray sandy dolomite
1,305	White fresh chert and light gray oölitic dolomite
1,320	Light gray sandy dolomite
1,332	Gray subangular etched coarse-grained sand showing much secondary growth of quartz grains
1,357	Light to gray slightly granular sandy dolomite with oölitic white chert
1,367	White angular coarse loose sand with much secondary growth
1,371 Total depth	No samples

TRENTON ROCK OIL COMPANY'S CARPER NO. 13, CLARK COUNTY, ILLINOIS

Sec. 30, T. 10 N., R. 13 W.
Elevation, 610 feet
Total depth, 3,411 feet

Depth in Feet	
1,550	No samples; no record to 1,285
1,285–1,330	Sand; Carper sand, Mississippian
1,340	Shale
1,395	Sand
1,415	Shale
1,425	Limestone (Rockford of Indiana)
1,550	Black shale; Chattanooga

DEVONIAN LIMESTONE

1,570	Light gray mottled limestone
1,582	Dark gray shaly limestone; hackly fracture; phosphate nodules and white fresh chert; crinoid stems
1,600	Light amber crystalline to finely crystalline sucrose dolomite
1,610	Light gray mottled limestone
1,655	Light gray limestone; white weathered dolomitic chert
1,682	Gray granular dolomitic limestone; many crinoid stems
1,740	Brown porous granular dolomite with angular medium-grained sand inclusions
1,775	White fresh to weathered dolomitic chert in light gray sandy slightly sucrose dolomitic limestone

Depth in Feet

SILURIAN (?)

1,785	White finely crystalline to crystalline limestone with included fragments of light green shale
1,870	Light gray limestone; white to gray fresh chert
1,880	Dark gray shaly limestone and calcareous shale
1,928	Light gray finely crystalline to crystalline sucrose dolomite and white fresh to weathered dolomitic chert
1,950	Same chert; light gray dolomitic limestone
1,990	No chert; light gray dolomitic limestone
2,030	Light gray limestone; light gray opalescent chert
2,074	Light gray limestone
2,085	Greenish gray micaceous shale
2,165	Light gray limestone
2,255	Light gray limestone; light to gray fresh chert
2,280	Light gray dolomitic limestone
2,290	Light gray limestone with red shaly spots

CATARACT (?) FORMATION

2,320	Dark red shaly limestone
2,328	Dark red shaly limestone and red shale
2,340	Light gray to pink limestone
2,392	Light gray limestone with pink spots
2,405	Light gray to red shaly
2,420	Light gray to pink limestone
2,435	Light gray limestone and white opalescent fresh chert

MAQUOKETA SHALE

2,445	Greenish gray shale
2,455	Gray very fine-sized well cemented sand
2,482	Gray fine- to coarse-grained shale
2,510	Light gray coarsely crystalline mottled limestone
2,565	Same with gray fresh black spotted chert
2,590	No samples
2,595	Gray shaly limestone
2,696	Gray micaceous shale

KIMMSWICK LIMESTONE

2,710	Light gray to amber slightly calcitic limestone
2,755	Light gray to amber finely crystalline to crystalline limestone
2,780	Light gray gnarly finely crystalline to crystalline limestone
2,825	Light brown coarsely crystalline
2,862	Light brown fine to coarsely crystalline calcitic limestone

DECORAH SHALE

2,867	Dark green shale fragments and above limestone

PLATTEVILLE LIMESTONE

2,875	Light gray dense limestone and gray and brown chert and leached green greasy pyritic shale fragments
2,910	Gray to amber finely crystalline to dense limestone
2,915	Above limestone and 50 per cent gray crystalline dolomite
2,962	Light gray hard limestone
2,968	Amber to gray soft limestone
3,000	Dark gray shaly limestone
3,075	Light gray to amber finely crystalline to dense limestone
3,085	Brown granular dolomite
3,100	Traces of dolomite; light gray dense to finely crystalline limestone
3,110	Brown crystalline dolomite and white weathered chert
3,115	Light gray finely crystalline to dense
3,135	Same limestone with light gray fresh chert
3,180	Light gray-amber finely crystalline to dense limestone
3,212	Light gray dense limestone

Depth in Feet	
	JOACHIM (?) FORMATION
3,245	Light gray granular dolomite and above limestone
3,260	Mostly dolomite
3,273	Buff very finely crystalline dolomitic limestone
3,280	Buff dense dolomite
3,295	Mostly dark gray shaly limestone
3,302	Amber dense limestone
3,315	Buff dense to finely crystalline dolomite
3,321	White anhydrite
3,335	White anhydrite and light gray dense dolomite
3,355	Light to dark gray shaly dolomite
3,360	Dark green sandy shale
3,370	Gray and brown sandy dolomite
3,380	Light gray dense sandy dolomite
3,393	Light gray to brown sandy dolomite
	ST. PETER SANDSTONE (?)
3,411 Total depth	Gray coarse etched to frosted subrounded well cemented to porous sand

JERVIAN CORPORATION'S BRIAR HILL NO. 1, COLLIERIES, OVERTON COUNTY, TENNESSEE

1 mile west of county line in southeast corner of county
Elevation, 1,845 feet
Total depth, 3,020 feet

Depth in Feet	
	PENNSYLVANIAN
80	Gray sandy shale
90	Light to dark gray shaly limestone
188	No samples; broken sand
192	No samples; coal
218	No samples; broken sand
228	No samples; sand
238	No samples; broken sand
240	No samples; coal
300	Light gray porous angular coarse-grained sand
310	Gray to brown hard limestone
400	No record
410	Gray fine-grained micaceous shale
460	No record
470	Above shale and fragments of dark gray shaly dolomite
510	No record
	CHESTER (?) MISSISSIPPIAN
520	Gray and brown oölitic slightly shaly limestone
710	No record
720	Light gray crinoidal limestone; possibly St. Genevieve
760	No record
770	Light gray oölitic limestone
810	No record
820	Light gray oölitic limestone
860	No record
920	Light gray hard limestone, large oölites
	ST. LOUIS (?) LIMESTONE
960	Light gray very finely crystalline limestone and light gray fresh chert
980	Light gray to amber finely crystalline limestone
990	Brownish hard dolomite, 85 per cent; limestone, 15 per cent
1,000	Dolomite, 40 per cent; limestone, 60 per cent; brown to opal fresh chert
1,020	Dolomite and 30 per cent anhydrite
1,040	Gray to amber hard limestone; opalescent chert
1,060	Gray to amber hard limestone
1,085	Gray to amber hard limestone and anhydrite

Depth in Feet	
1,090	Gray to amber hard limestone
1,100	Dark gray coarse-grained micaceous shale
	SPERGEN (?) LIMESTONE
1,150	Gray to brown mottled limestone with angular sand inclusions
	OSAGE (?) GROUP
1,170	Dark gray shaly limestone
1,193	Gray granular finely crystalline dolomite
1,202	Dark gray shale
1,210	Dark gray shaly dolomite
1,220	Gray crystalline to finely crystalline sucrose dolomite
1,260	Light gray fresh chert and finely crystalline sucrose dolomite
1,270	Brown finely crystalline granular dolomite and above chert
1,310	Light gray finely crystalline granular dolomite and above chert
1,360	White finely crystalline granular dolomite and above chert
1,400	Gray dolomite and light gray fresh chert
	CHATTANOOGA SHALE
1,420	Black fine-grained micaceous shale
	CINCINNATI GROUP
1,442	Brownish granular crystalline to finely crystalline dolomite
1,470	Dark gray shaly limestone
1,512	Dark gray shaly limestone and dark gray shale streaks
1,530	Dark gray shale
1,540	Gray shaly granular dolomite and dark gray shale, micaceous
1,595	Dark gray micaceous shale; thin streaks shaly limestone
1,640	Light gray limestone; streaks of shale
1,670	Gray to dark gray shaly limestone
1,700	Above limestone and gray shale
	TRENTON LIMESTONE
1,770	Gray to brown hard finely crystalline limestone
1,780	Same and gray fresh chert
1,800	Same, no chert
1,810	Gray to brown limestone; brown fresh chert
1,900	Gray to brown limestone
1,918	Gray shaly limestone
1,932	Dark gray micaceous shale
1,970	Gray shaly limestone
	BLACK RIVER GROUP
1,972	Light green pyritic greasy shale; pencil cave of the drillers
2,015	Gray to amber dense limestone; brown fresh chert
2,040	Gray to amber dense limestone
2,070	Brown granular dolomitic limestone
2,135	Gray to amber dense to finely crystalline limestone with brown and gray fresh chert
2,160	Limestone the same; no chert
2,220	Gray lithographic limestone
2,490	Gray to amber lithographic limestone
	STONES RIVER GROUP
2,500	Gray to amber shaly limestone
2,510	Gray to amber shaly limestone; brown fresh chert
2,530	Gray to amber shaly limestone
2,600	Amber dense limestone; trace dark gray shaly
2,630	Amber dense to dark gray shaly limestone
2,720	Dark gray shaly dense limestone
2,740	Gray to amber dense; trace shaly
2,810	More shaly

Depth in Feet	
2,840	Light gray dense limestone
2,850	Light gray finely crystalline granular dolomite
2,860	Dark gray shaly limestone

KNOX DOLOMITE

2,890	Gray to amber finely crystalline to crystalline dolomite
2,900	Gray to greenish granular crystalline dolomite; rounded sand inclusions
2,920	Gray to greenish granular crystalline dolomite
2,940	Gray to amber sandy finely crystalline to crystalline dolomite
2,950	Not sandy
2,980	Light gray to white finely crystalline granular sandy dolomite
3,010	Light gray to white finely crystalline granular dolomite

PINE KNOT OIL COMPANY'S WELL, MCCREARY COUNTY, KENTUCKY

1 mile north of Pine Knot station
Total depth, 2,511 feet

PENNSYLVANIAN

Depth in Feet	
25	No record
95	Gray fine-grained well cemented shaly micaceous angular arkosic sandstone
200	Coarser sand
215	Gray micaceous shale
240	White medium-grained porous micaceous arkosic angular sand
300	No record
310	Gray coarse-grained angular arkosic sand
320	Gray micaceous shale
350	Shale and fine-grained sand streaks
370	Gray shale
420	Gray fine- to coarse-grained porous micaceous angular sandstone
440	Gray shale with some coal
500	White very coarse-grained angular sand
510	Gray shale and coal
560	Gray micaceous shale
585	Gray micaceous shaly fine-grained sand
608	Dark gray sideritic shale
660	Light gray medium-grained micaceous angular sand
675	Dark gray shale
695	Gray shaly sand
700	Coal and dark gray shale
730	Dark gray shale
740	Gray fine-grained angular well cemented micaceous sand
750	Coal and dark gray micaceous shale
765	Gray fine-grained angular well cemented micaceous sand
785	Gray shale
800	Gray medium- to coarse-grained angular sand
810	Black shale and coal
830	Streaks shale and coarse-grained sandstone

BASE PENNSYLVANIAN—TOP CHESTER

845	Greenish gray shale
875	Red to green shale
900	Gray micaceous shale
930	Gray mottled finely crystalline limestone
945	Brown sucrose dolomite; white fresh chert
955	Above, dolomite and gray shale
980	White finely crystalline slightly oölitic limestone
985	Gray shale
1,025	Light to gray slightly mottled limestone
1,038	Greenish gray micaceous shale

Depth in Feet	
	TOP OF MERAMEC (?)
1,070	Light gray oölitic limestone
1,100	Light gray non-oölitic limestone
1,110	Light gray dense limestone
1,125	Light gray oölitic limestone
1,230	No record
1,270	Light gray finely crystalline limestone
	OSAGIAN (?)
1,275	Gray shaly limestone
1,300	Gray to brown slightly granular dolomite
1,322	Same trace of greenish dolomite
1,332	Gray shale
1,340	Gray sandy limestone
1,360	Gray to brown limestone
1,370	Greenish gray medium-grained well cemented calcareous angular sand
1,430	Streaks of shaly lime and limy shale; some chert
1,450	Light gray mottled limestone and gray opalescent chert
1,470	Gray granular cherty dolomite
1,490	Dark gray shaly cherty dolomite
1,495	Gray shale
1,560	Light gray slightly granular dolomite with light gray opalescent chert
1,575	Gray to greenish shaly dolomite
1,595	Dark red to greenish shale
1,610	Gray shale
	CHATTANOOGA SHALE
1,650	Dark gray to black shale; small *Sporangites huronense*
1,660	Black to greenish micaceous shale
1,675	Above with some greenish shaly dolomite
	CINCINNATI GROUP
1,720	Green fine-grained slightly micaceous shale
1,730	Red oölitic shale
1,760	Gray crystalline granular dolomite
1,830	No record
1,880	Dark red to green shale and gray limestone streaks
1,915	Shale and limestone
1,940	Dark gray shaly limestone
2,005	Dark gray to red shaly limestone, 30 per cent; gray shale, 70 per cent
2,035	Limestone, 60 per cent; shale, 40 per cent
2,050	Dark gray shale
2,100	Light gray mottled limestone, 60 per cent; shale, 40 per cent; many bryozoans
2,140	Light gray mottled limestone; 15 per cent shale
	"TRENTON" (?) LIMESTONE
2,200	Light gray finely crystalline limestone
2,290	Same with thin shale streaks
2,315	Gray fresh chert with light to dark mottled limestone
2,325	Gray shale, 80 per cent; limestone, 20 per cent
2,355	Above limestone, 90 per cent; shale, 10 per cent
2,375	Gray hard slightly shaly limestone
2,385	Same limestone with gray fresh chert
2,405	Gray slightly shaly limestone
2,440	Above limestone with gray fresh chert
	BLACK RIVER BEDS
2,450	Green greasy bentonitic shale and light brown gnarly finely crystalline limestone
2,500	Same limestone
2,511	Same limestone with dark gray shaly limestone fragments
Total depth	

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1560-1578, 8 FIGS.

JESSE POOL, PONTOTOC AND COAL COUNTIES, OKLAHOMA[1]

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Ponca City, Oklahoma.

ABSTRACT

The development of the Jesse pool, located in the southeast part of the Franks graben, followed shortly after the discovery of the Fitts pool. Both the stratigraphy and the geological history of these pools are closely related. The Jesse pool lies on a large anticline, which is faulted on the south side. The faulting ordinarily occurs as a series of step faults, and is regarded as the controlling factor for trapping the oil. This anticline is almost as large as the Fitts anticline, but generally, the porosity and permeability of the reservoir rocks are not as good. Consequently, the productivity will be considerably less in the Jesse pool than in the Fitts pool. The major structural movements of the Arbuckle Mountains are reflected in the Jesse anticline; the first major structural uplift occurred at the close of Atoka time (early Pennsylvanian), and the second major uplift occurred in the late Pennsylvanian time. Oil or gas is produced from rocks of Pennsylvanian, Siluro-Devonian, and Ordovician age, at depths ranging from 1,800 feet to 4,700 feet. The most prolific production is from the "Wilcox" sand at the crest of the anticline.

Introduction

The development of the Fitts pool stimulated the search for other pools in southeastern Oklahoma, in Pontotoc, Coal, Atoka, and eastern Hughes counties. The Jesse pool was the first of several pools to be discovered and the only one of importance, besides the Fitts pool, that has been found. The results of tests on other structures east and southeast of this area have been disappointing.

The Jesse pool extends from the northwest corner of T. 1 N., R. 8 E., through the northeast part of T. 1 N., R. 7 E., into Sec. 33, T. 2 N., R. 7 E. (Fig. 1). The portion of the area in Sec. 4, T. 1 N., R. 7 E., and Sec. 33, T. 2 N., R. 7 E., is called the South Fitts pool in the reports of the Corporation Commission of the State of Oklahoma. The writer considers that the South Fitts pool and the Jesse pool are closely related structurally, and their connection will eventually be proved. They are considered as one pool in this report. The Jesse pool is directly southeast of the Fitts pool, and extends within 1 mile of it in Sec. 33, T. 2 N., R. 7 E.

History of Development

The Anderson and Kerr Drilling Company *et al.* Thompson No. 1 discovered oil in commercial quantity in the Jesse pool, in the Hunton limestone at a depth of 3,835 feet, in the SW.$\frac{1}{4}$, NE.$\frac{1}{4}$, SW.$\frac{1}{4}$ of Sec. 1, T. 1 N., R. 7 E. The well was drilled to 4,656 feet, into the Bromide

[1] Read by title before the Association at New Orleans, March 17, 1938. Manuscript received, June 6, 1938.

[2] Geologist, Continental Oil Company.

sand, where salt water was encountered. A showing of oil was found in the Viola limestone, but it was regarded as non-commercial. The salt water was plugged off, and the well was completed on February 2, 1935, with an initial production of 87 barrels from the Hunton limestone.

Nine months later, the Continental Oil Company discovered oil in the "Wilcox" sand from 4,621 feet to 4,633 feet in its McCarty

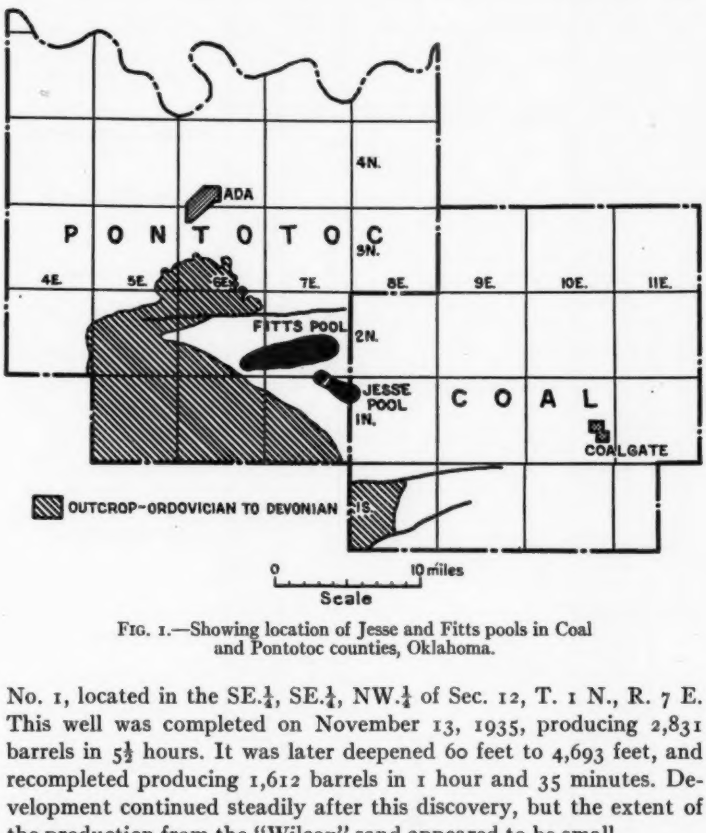

FIG. 1.—Showing location of Jesse and Fitts pools in Coal and Pontotoc counties, Oklahoma.

No. 1, located in the SE.$\frac{1}{4}$, SE.$\frac{1}{4}$, NW.$\frac{1}{4}$ of Sec. 12, T. 1 N., R. 7 E. This well was completed on November 13, 1935, producing 2,831 barrels in $5\frac{1}{2}$ hours. It was later deepened 60 feet to 4,693 feet, and recompleted producing 1,612 barrels in 1 hour and 35 minutes. Development continued steadily after this discovery, but the extent of the production from the "Wilcox" sand appeared to be small.

On the top of this anticline, the Bromide and McLish formations produce gas only, and very little oil in the wells located lower, structurally. This condition slowed the development of the Jesse pool until it was further stimulated by a northwest extension by the Sunray Oil

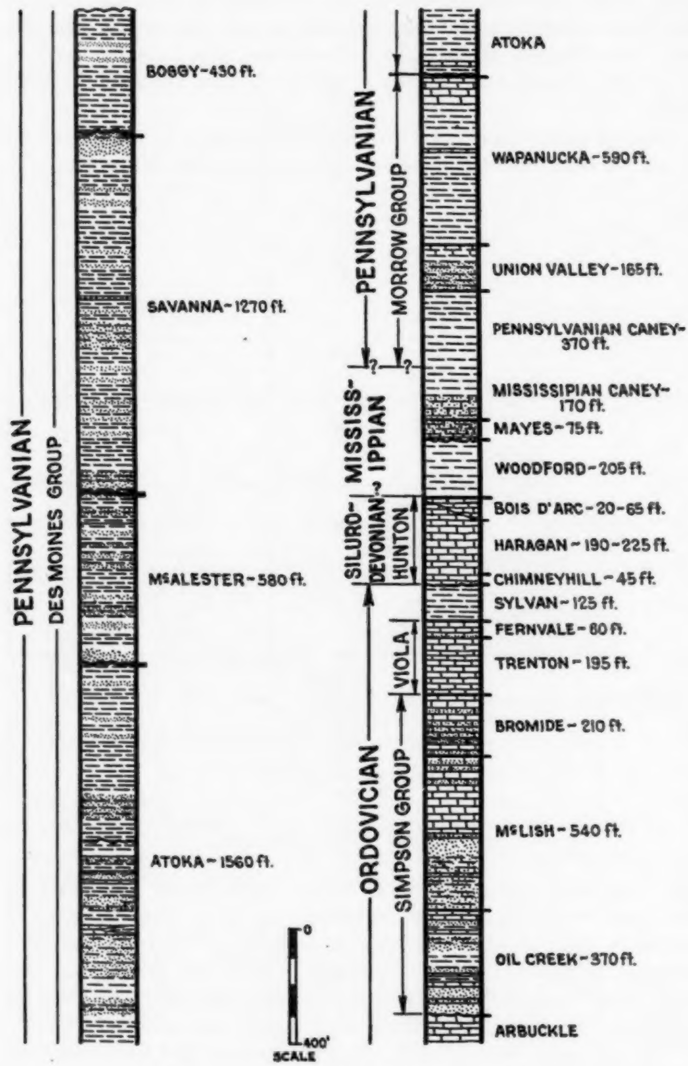

FIG. 2.—Normal geologic section of Jesse pool.

Company's Schumard No. 1, in the NE.¼, SW.¼, SE.¼ of Sec. 2, T. 1 N., R. 7 E. The Bromide sand was found well developed from 4,535 feet to 4,559 feet, and the well was completed with a tubing potential of 1,302 barrels per day.

Exploring down the flank of the structure from the Schumard well, the Continental Oil Company completed G. L. Thompson No. 1, in the SW.¼, SW.¼, NE.¼ of Sec. 2, T. 1 N., R. 7 E., in the Hunton limestone, producing 435 barrels in 3 hours. This stimulated the search for oil from this formation. Development of the Hunton has proceeded slowly, but steadily, since the completion of the Thompson well, May 17, 1937.

The Jesse pool is now about 4 miles long and 1 mile wide.

STRATIGRAPHY

The stratigraphy of the Jesse pool (Fig. 2) is similar to that of the Fitts pool,[3] except for such minor variations in character and thickness as are noted.

ORDOVICIAN ROCKS

Arbuckle limestone.—The Arbuckle limestone is the oldest formation penetrated in the Jesse pool. Only one well, Continental's Simpson No. 2, in the SW.¼, SE.¼, NE.¼ of Sec. 12, T. 1 N., R. 7 E., has been drilled into the Arbuckle, penetrating it 87 feet.

This part of the Arbuckle is mostly white to buff, finely crystalline dolomite, with a bed of sandy dolomite near the top, a bed of white oölitic chert 40–50 feet from the top, and some thin streaks of bright green shale 60–70 feet from the top.

The Arbuckle is approximately 8,000 feet thick in the outcrop in the adjoining mountains, and has been completely described by C. E. Decker and C. A. Merritt.[4]

SIMPSON GROUP

The Simpson group, in the Jesse pool, is composed of the Bromide, McLish, and Oil Creek formations.

Oil Creek formation.—The Oil Creek formation lies on top of the Arbuckle limestone. It is 370 feet thick in Continental's Simpson No. 2, and is composed of an alternating series of limestones, sandstones, dolomites, sandy dolomites, and green shales. The limestone marking the top of the Oil Creek is a somewhat distinctive limestone, and read-

[3] Don L. Hyatt, "Preliminary Report on the Fitts Pool, Pontotoc County, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 7 (July, 1936), p. 951.

[4] C. E. Decker and C. A. Merritt, "Physical Characteristics of the Arbuckle Limestone," *Oklahoma Geol. Survey Circ. 15* (1928).

ily differentiated from those in the formations above. It is mottled gray to white, medium to coarsely crystalline fossiliferous limestone. Some of the sandstones in the Oil Creek are stained with oil, and may produce oil on the crest of the Jesse anticline.

McLish formation.—The McLish formation lies on top of the Oil Creek formation with an average thickness of 535 feet. The lower 140 feet is a series of interbedded sandstones, dolomites, limestones, and green shales. The sandstones are oil-stained in Continental's Simpson No. 2, and may produce oil at a higher structural location.

Immediately above this series, and approximately 290 feet from the top of the McLish formation, is soft, fine- to medium-grain rounded to subangular sandstone, which is the most prolific oil producer in the pool. It is generally called the "Wilcox" sand, and has been correlated with the "Second Wilcox" sand of the Seminole area by several geologists familiar with the Ordovician section between the Fitts pool and the oil pools of the Seminole area. The writer has not studied this correlation; consequently, he can not verify it. This sand is correlative with Hyatt's Fifth McLish sand in the Fitts pool.[5] The "Wilcox" sand is approximately 110 feet thick with thin lenses of dolomite and green shale occurring throughout.

The upper half of the McLish formation is an alternating series of massive, dense limestones, and thin-bedded dolomites, which are interbedded with thin beds of green shale. In the series, approximately 50 and 90 feet from the top of the McLish, are thin sandy dolomites about 10 and 20 feet thick, respectively, which are correlated with the First and Second McLish "sands" in the Fitts.[6] The first "sand" is lenticular, the second "sand" is continuous. These sandy dolomites produce only gas on the crest of the structure. At structurally lower positions they make very poor wells, which, at present, are considered non-commercial.

A gray and buff to white, dense limestone, which in places has a greenish cast, is found between the first and second "sands." It is about 25 feet thick, and is a good structural marker for the McLish formation. In the early development of the pool it was considered that this limestone marked the top of the McLish. Later development, however, proved that this top was too low if correlated with the Fitts pool section. The top of the McLish is usually determined by the presence of dense limestone below the sandy Bromide section. It is not extensive over the entire pool, and in places grades into dolomite or finely crystalline dolomitic limestone.

[5] Don L. Hyatt, *op. cit.*

[6] Don L. Hyatt, *op. cit.*

Bromide formation.—The Bromide formation, approximately 210 feet thick, rests unconformably on the McLish formation.[7] It consists mainly of limestone with an interbedded series of sandy limestones and some thin beds of sandstone in the lower half. Thin beds of dolomite are found erratically throughout the section. Only one sandstone, near the base, produces oil in this section. This sand is very lenticular, in places grading into limestone or dolomite in one location. It is well developed, about 12 feet thick, in parts of Sec. 2, T. 1 N., R. 7 E. where several good wells have been completed. Like the upper McLish "sands," it produces only gas on the crest of the structure. It is correlated approximately with the Second Bromide sand of the Fitts pool.

The top of the Bromide is satisfactorily determined by the presence of a 5–25-foot bed of buff to brown, dense limestone.

Viola limestone.—The Viola limestone rests conformably on the Bromide formation, and has an average thickness of 255 feet. It is divided into two members: the lower Trenton Viola which has an average thickness of 195 feet, and the upper or Fernvale limestone which has an average thickness of 60 feet.[8]

These two members are quite different in lithologic character, and are easily distinguished one from the other. The Trenton Viola is massive, brown, finely crystalline limestone, dolomitic in part. It has two cherty zones which are good markers: buff to brown chert, 40–60 feet from the top of the Trenton, and bluish gray chert, 20–40 feet from the base. The Fernvale limestone is the typical coarsely crystalline, mottled gray to white limestone with some pink crystals, which is widespread in Oklahoma. The basal 5 feet of the Fernvale is very sandy.

Like the pay zones in the Bromide and McLish formations, the Viola produces only gas on the crest of the anticline. Several wells on the north flank of the anticline produce oil from the Viola only. The Trenton Viola furnishes most of the oil, although the thin sandy limestone at the base of the Fernvale contributes some.

Sylvan shale.—The Sylvan shale lies on the Viola limestone. It is smooth-textured, greenish gray shale with an average thickness of 125 feet. The bottom 10–25 feet is ordinarily interbedded or mottled with brown shale.

[7] C. E. Decker, C. A. Merritt, and R. W. Harris, "The Stratigraphy and Physical Characteristics of the Simpson Group," *Oklahoma Geol. Survey Bull. 55* (1931), p. 50.

[8] C. E. Decker, "Viola Limestone, primarily of the Arbuckle and Wichita Regions of Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, No. 12 (December, 1933), pp. 1405–35.

SILURO-DEVONIAN ROCKS

Hunton limestone.—The Hunton limestone overlies the Sylvan shale with an average thickness of 300 feet. It is easily divided into three members: the Chimneyhill, Haragan, and Bois D'Arc limestones.

Hyatt has explained the correlation of these members with the outcrop in the Arbuckle Mountains a short distance away.[9]

The Chimneyhill limestone, approximately 45 feet thick, is the lower member. It is easily divided into three parts: a 5–10-foot oölitic limestone at the base, about 20 feet of white finely crystalline, glauconitic and cherty limestone in the middle, and the pink crinoidal member at the top, approximately 15 feet thick.

The Haragan limestone, approximately 220 feet thick, is the middle member. It is greenish gray to light gray, finely crystalline, somewhat dolomitic limestone.

The Bois D'Arc limestone, 20–65 feet thick, is the upper member. It is white, medium to coarsely crystalline limestone with white translucent chert, ordinarily present at the top, and occurring erratically throughout this member.

Accumulation of oil in the Hunton is confined to the north flank of the anticline. Oil and gas are produced from the upper part of the Bois D'Arc limestone and the oölitic bed in the Chimneyhill limestone. Only gas is present on the crest of the Jesse structure.

MISSISSIPPIAN ROCKS

Woodford shale.—The age of the Woodford shale is questionable; many geologists consider that it is Devonian in age. It has an average thickness of 205 feet, and lies unconformably on the Hunton limestone. It is dark brownish black shale with bands of dark gray to black chert here and there, and is characterized by many *Sporangites* and some conodonts. Some of the browner beds are oily in character. A distillation test shows an asphaltic (?) residue; however, to the writer's knowledge, no free oil has ever been produced from the Woodford.

Mayes "limestone."—The Mayes "limestone" is correlated with the Sycamore limestone, and lies unconformably on the Woodford shale. At this contact the Weldon limestone is found in some places. The Weldon is greenish white, finely crystalline, granular limestone with maximum thickness of 9 feet.

The Mayes "limestone" is brown calcareous, shaly grit, in places grading downward into buff to brown, finely crystalline, somewhat glauconitic gritty limestone. A very glauconitic phase of the Mayes occurs at the base, and is a good horizon marker. The top of the

[9] Don L. Hyatt, *op. cit.*

Mayes grades upward into the Mississippian Caney shale. This gradation is so variable that the top of the Mayes is an unreliable datum for structural control. Its average thickness is 75 feet.

Mississippian Caney.—Next above the Mayes is the Mississippian Caney which has an average thickness of 170 feet. It is mostly brownish black shale which becomes calcareous and gritty as it grades into the underlying Mayes. These beds of thin calcareous grit are commonly called "False" Mayes in the field. Thin lenticular beds of dark brown limestone are present in the upper part, and a bed of globular glauconite ordinarily identifies the top. As the top is generally difficult to place, it can not be relied on for detailed structural control. Conodonts are common in the shale.

PENNSYLVANIAN ROCKS

MORROW GROUP

Pennsylvanian Caney.—The Pennsylvanian phase of the Caney shale has an average thickness of 270 feet. It is dark gray to black, splintery shale characterized by fine-grained, rounded sand grains, disseminated throughout. Brown clay ironstone or sideritic concretions are ordinarily present in the lower part.

Union Valley formation.—Next above the Pennsylvanian Caney is the Union Valley formation, approximately 165 feet thick, which may be divided into two parts. The lower part, about 115 feet thick, is dark gray shale with thin interbedded layers of dark gray to gray and buff, medium-grained, angular, glauconitic sand. The sand is ordinarily calcareous and in places shaly. This sand is correlated with the Cromwell sand. Oil staining is in places noted in the more porous beds, but at present none of this sand has been developed enough to expect commercial production. It is expected that down the flank of the Jesse anticline in the direction of the Fitts pool, oil in commercial quantities will be found where the Cromwell is well developed. This sand produces oil in the eastern part of the Fitts pool.

The upper 50 feet is predominantly dark gray, finely crystalline, glauconitic, shaly limestone, interbedded with gray shales. The top of the Union Valley is an excellent horizon for structural control.

Wapanucka formation.—The Wapanucka formation overlies the Union Valley with an average thickness of 590 feet. The lower 490 feet is predominantly dark gray shale with thin lentils of calcareous sandstone here and there. In this zone, approximately 250 feet from the top of the formation, is a thin lenticular bed of limestone about 10 feet thick. It is dark brown, finely crystalline, oölitic limestone, the oölites being much larger than those in the upper member.

The upper limestone is the Wapanucka limestone, which marks the top of the formation. This limestone, approximately 100 feet thick, is buff to white, grading downward to gray, and is oölitic throughout. At the top of the Wapanucka, and present over most of the pool, is an angular, medium-grained, lenticular sandstone, ordinarily containing weathered or reworked oölites. Where present, its average thickness is 10 feet. This sand produces gas in three wells in the Jesse pool, and is expected to produce gas on most of the structure. The Wapanucka limestone is the best marker in the Pennsylvanian system in this general area.

DES MOINES GROUP

Atoka formation.—The Atoka formation lies unconformably on the Wapanucka. It consists of an alternating series of sandstones and shales with some limestone lentils in the middle part of the formation. The many beds in the Atoka are all lenticular in character. The sandstones are ordinarily calcareous, in places almost quartzitic, and in many places conglomeratic with fragments of limestone and chert here and there. A study of the stratigraphy of the Atoka indicates that it was laid down rapidly, and is a near-shore phase.

About 600 feet above the base of the Atoka, is buff to white finely crystalline to cryptocrystalline limestone about 15 feet thick, which is a good marker. Just below this limestone is a lenticular sand, which is producing oil in three wells in the Jesse pool. This sand is correlated with the Gilcrease by some geologists who are familiar with both the Fitts-Jesse area and the Seminole area. Other sands in the Atoka formation contain good showings of oil, and it is expected that they will produce oil in commercial quantities.

About 1,100 feet above the base of the Atoka is a minor unconformity.

Near the top of the Atoka is a thin gas sand about 20 feet thick, which in some wells causes trouble by blowing mud out of the hole when it is first encountered by the drill.

The thickness of the Atoka ranges from 1,420 feet to 1,860 feet.

Hartshorne sandstone.—The presence of the Hartshorne sandstone has not been definitely established in the Jesse pool.

McAlester formation.—The McAlester formation lies unconformably on the Atoka formation, and is approximately 580 feet thick. It consists of greenish gray and gray shales interbedded with thin lenticular sandstones. Traces of coal are ordinarily observed. The formation crops out at the crest of the anticline.

The contact between the McAlester and the overlying Savanna

sandstone is not readily determined. The writer generally places the contact so as not to include any vari-colored shales.

Savanna sandstone.—The basal part of the Savanna sandstone forms an escarpment around the north flank of the Jesse anticline, on which the surface structure may be mapped. George D. Morgan determined that the thickness of the Savanna was approximately 1,300 feet, along the east line of T. 1 N., R. 7 E.[10] On the downthrown side of the Jesse fault zone, the Savanna is estimated to be 1,270 feet thick. It consists of an interbedded series of sandstones and shales. The shales are greenish gray and gray, and several zones of maroon and vari-colored shales are present.

Boggy formation.—The Boggy formation lies unconformably on the Savanna. Only a small part of this formation is present at the surface on the downthrown side of the Jesse fault. The maximum thickness of the Boggy, in the Jesse area, is approximately 430 feet. It is predominantly greenish gray shale with some lenticular beds of shaly sandstone, and is the youngest formation encountered in the Jesse pool.

Structural and Geological History

The Jesse pool lies in the southeast part of the Franks graben, as described by Morgan.[11] Within the Franks graben, he described the anticline under which both the Jesse and Fitts pools are located. Detailed work on the anticline in the vicinity of Jesse revealed that the anticline was essentially a tilted block, faulted on the south side. A subsurface study of the structure confirms this view (Figs. 3, 4, 5). This faulting has a maximum throw of 1,300 feet and occurs in zones of step faulting, all of which are normal (Figs. 7, 8). Some wells cut as many as five small faults before finishing on the upthrown side. Figures 7 and 8 illustrate the structural uplift. The uplifted block had a clockwise rotational movement, which caused the fault planes to bend and branch off, assume lesser angles, and to fade out into the overlying anticline. As a result of this rotational uplift, note the small graben in Figure 7, which dropped, presumably because of the tension developed between the upthrown and downthrown sides of the fault zone. Two patterns of faulting are developed in the Jesse pool (Figs. 3, 4, 5). The main fault which controls the production is parallel with the anticline, approximately N. 62° W. The secondary set extends approximately N. 63° E. or about 55° with the main set.

[10] George D. Morgan, "Geology of the Stonewall Quadrangle, Oklahoma," *Bur. of Geol. Bull. 2* (Norman, 1924).

[11] George D. Morgan, *op. cit.*

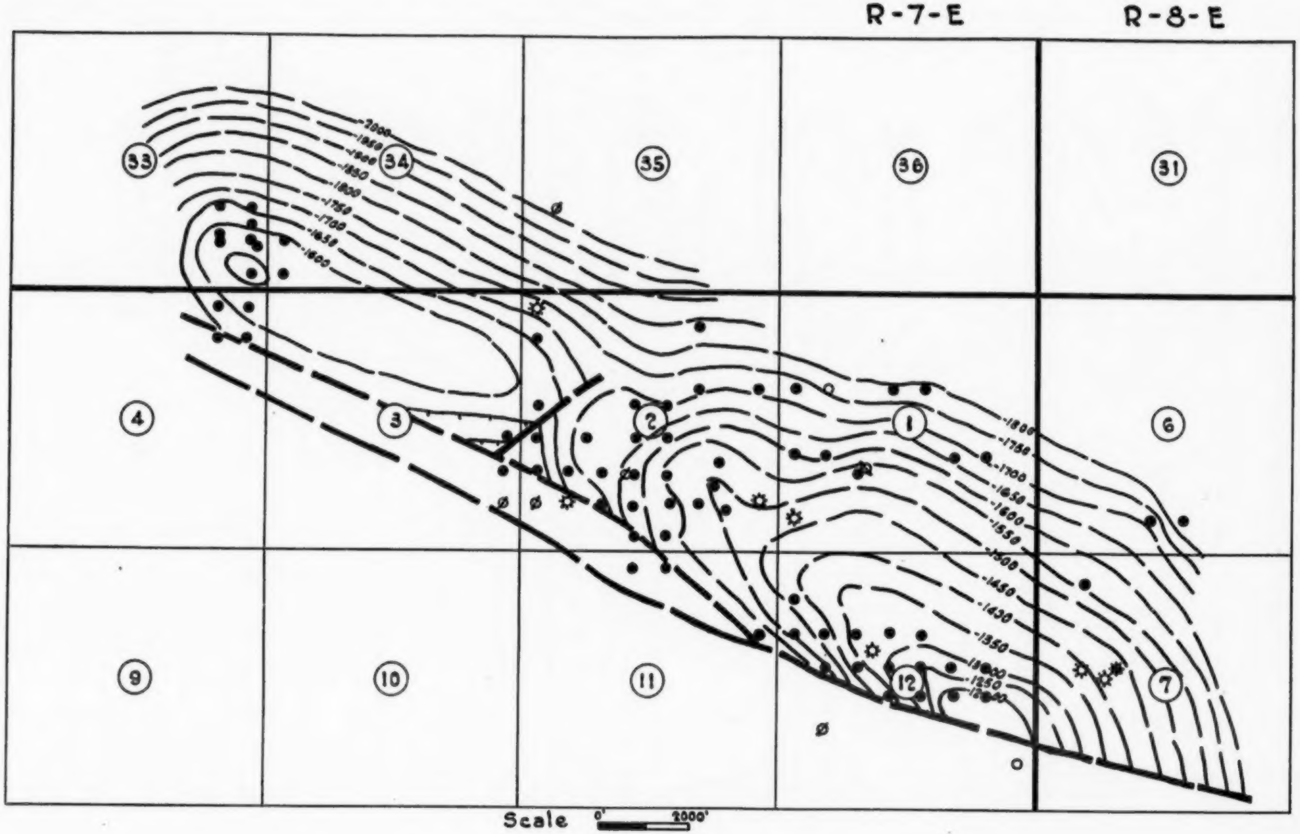

FIG. 3.—Contour map of Jesse pool. Datum, Wapanucka limestone. Contour interval, 50 feet.

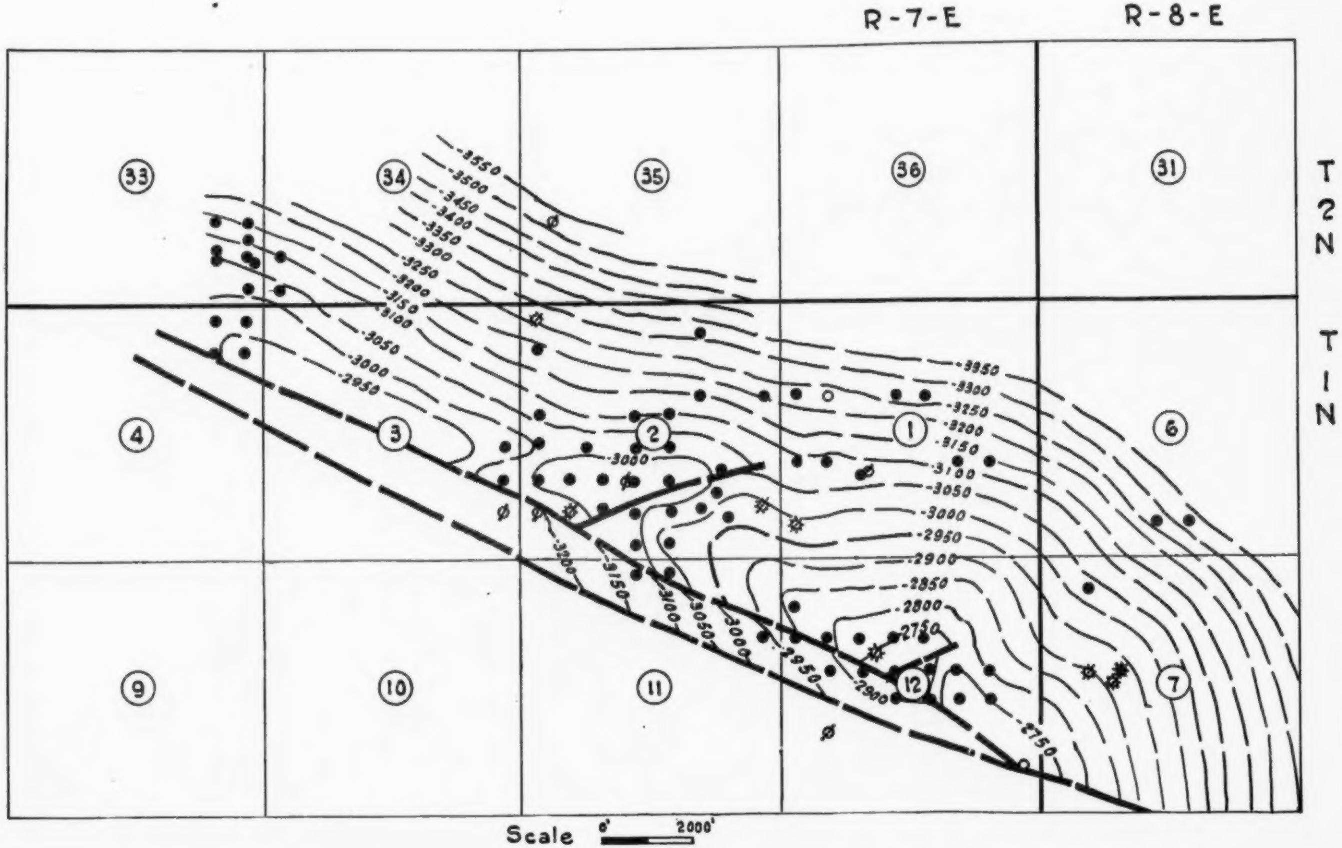

FIG. 4.—Contour map of Jesse pool. Datum, Hunton limestone. Contour interval, 50 feet.

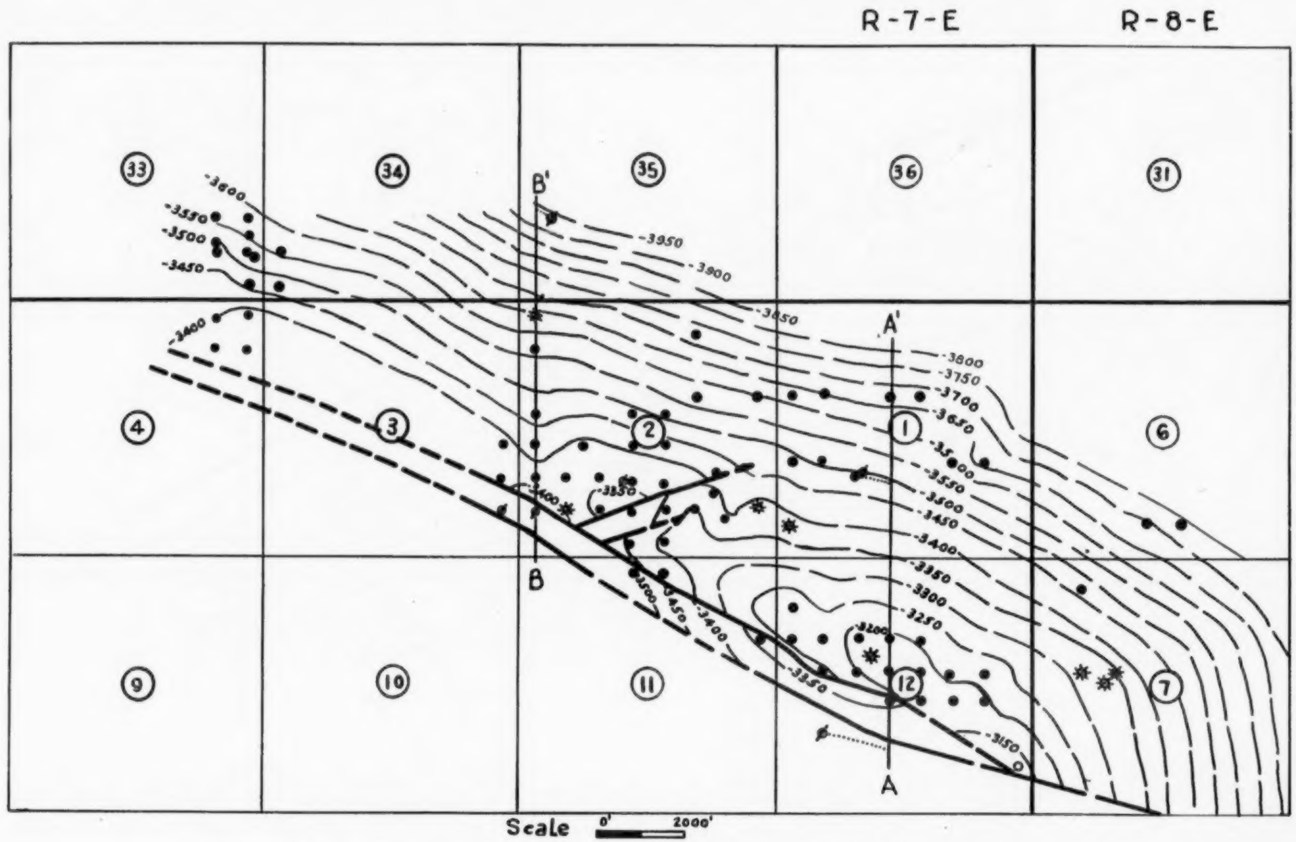

FIG. 5.—Contour map of Jesse pool. Datum, Viola limestone. Contour interval, 50 feet.

The geological history of the Jesse pool is similar to that of the Fitts pool[12] and the Arbuckle Mountains. The structural and geological history of the Arbuckle Mountains has been very well described by R. H. Dott.[13] The history of the Arbuckle Mountains is reflected in the Jesse pool.

There were periods of gradual oscillations throughout Ordovician, Silurian, Devonian, Mississippian, and into early Pennsylvanian time. At the close of Wapanucka time and in early Atoka time, the first major uplift occurred. This movement, however, was not as intense in the Jesse pool as it was in the Fitts pool. Throughout Atoka time, the Jesse area received frequent oscillations, and, near the end, became a positive element for short intervals. The greatest uplift occurred as Atoka time came to a close, and continued into early McAlester time. As much as 1,000 feet of sediments were probably removed. From this time until late Pennsylvanian, we must look to other areas to complete the history.

Surface faulting shows that the area was again affected in post-Boggy time, and probably in late Pennsylvanian, when the Arbuckle Mountains received their second great movement.

Oil Production

The production of oil from the Jesse pool may be generally divided into four zones and areas: (1) "Wilcox," (2) Bromide, (3) Hunton, and (4) Pennsylvanian.

1. The "Wilcox" oil production is confined to a small area on the crest of the structure (Fig. 6). The best production in the pool is found in this area. The average initial potential gauge was approximately 4,000 barrels a day. Twelve wells have been completed, and one was drilling, May 31, 1938. The water level is 3,980 feet below sea-level. The initial bottom-hole pressure was 1,940 pounds at −3,300 feet. After 1,101,755 barrels had been produced, the bottom-hole pressure had declined to 1,640 pounds, on January 1, 1938. The estimated ultimate production from the "Wilcox" sand is 6,650,000 barrels.

Five wells adjoining the "Wilcox" production produce oil from the upper McLish "sand" only (Fig. 6). These are regarded as non-commercial wells. The average initial production from these wells was 200 barrels a day.

One of the outstanding differences between the Jesse pool and the

[12] Don L. Hyatt, *op. cit.*

[13] Robert H. Dott, "Overthrusting in the Arbuckle Mountains, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, No. 5 (May, 1934), p. 567.

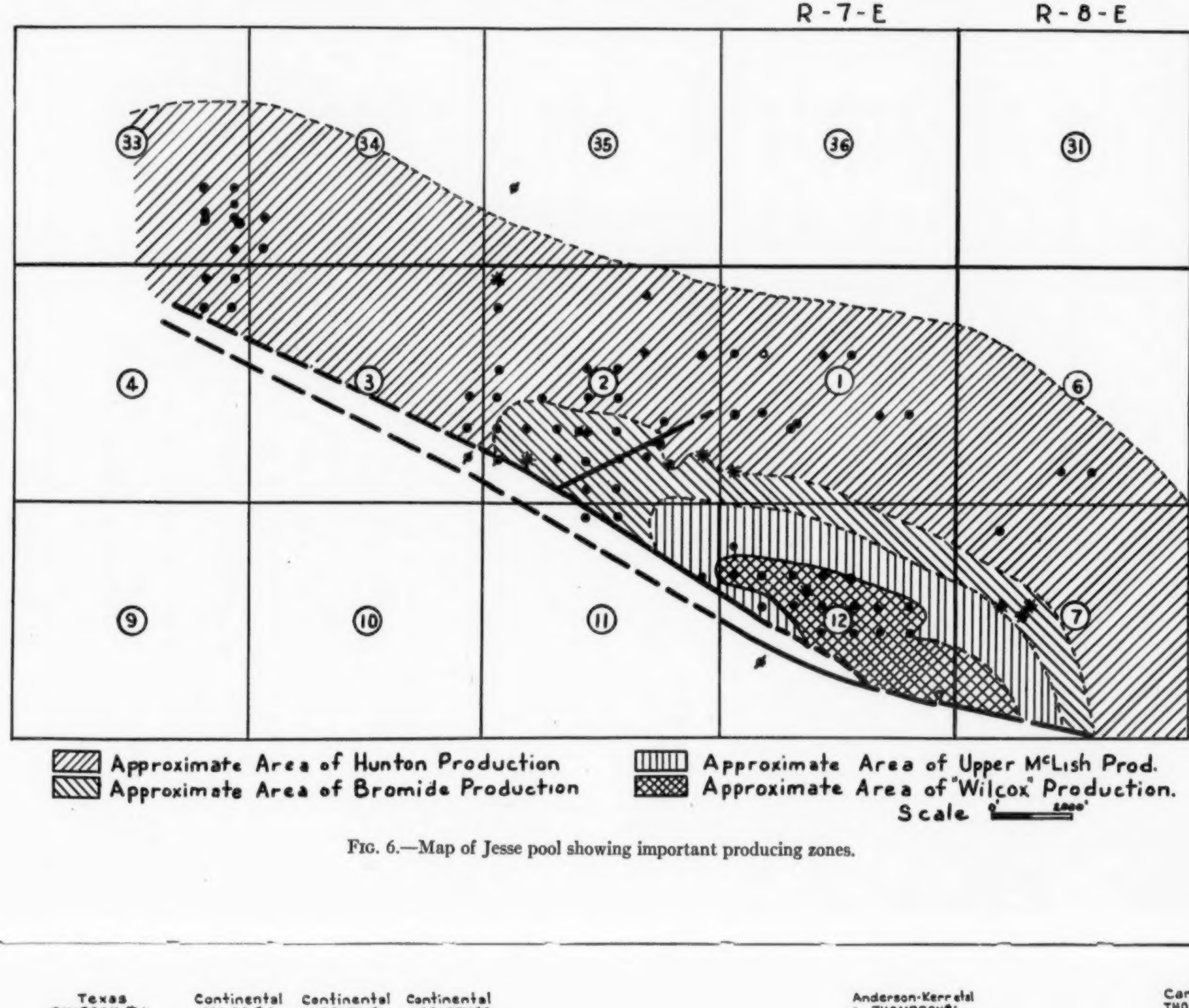

FIG. 6.—Map of Jesse pool showing important producing zones.

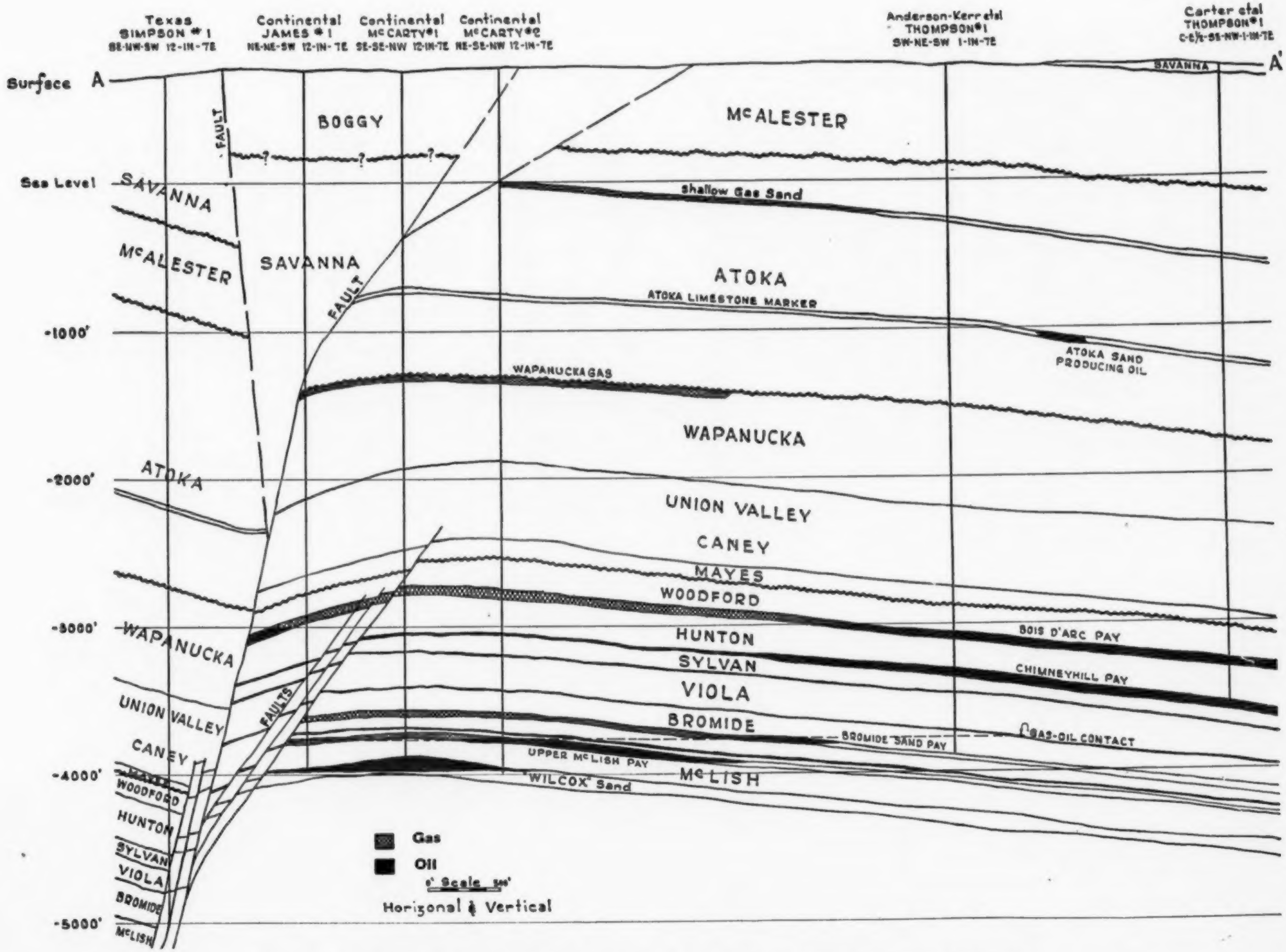

FIG. 7.—Cross section of Jesse pool showing position of producing horizons. See Figure 5 for location.

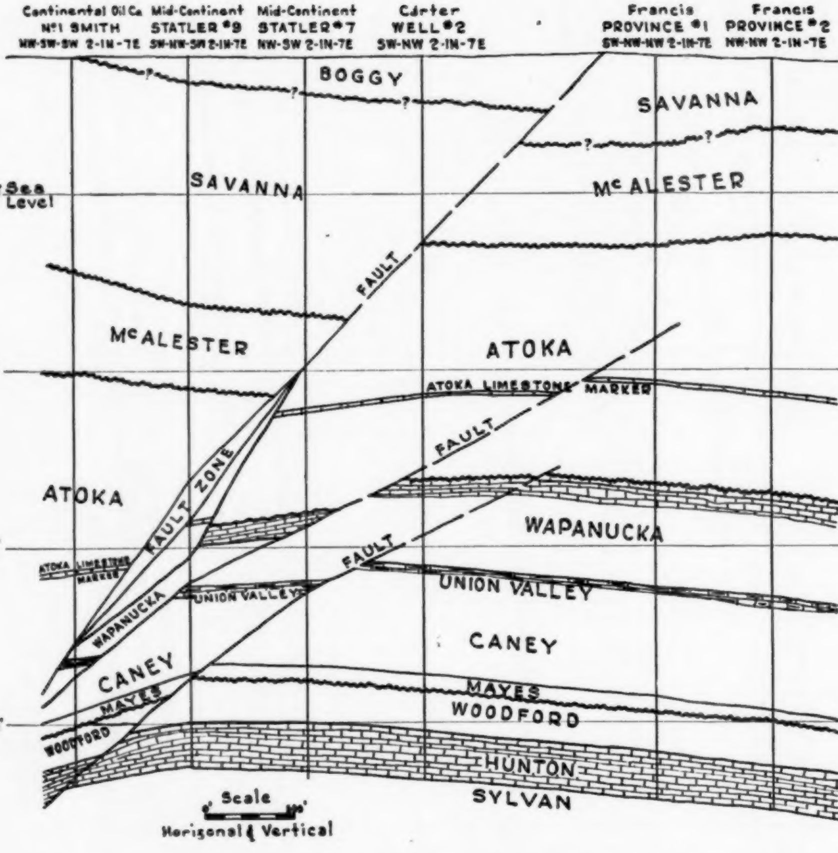

FIG. 8.—Cross section of Jesse pool showing complicated fault zone. See Figure 5 for location.

neighboring Fitts pool is the gas cap in all reservoir rocks in the upper McLish, Bromide, and Viola formations. This gas-oil contact is found approximately at 3,760 feet below sea-level. This fact, together with the relatively poorer character of these reservoir rocks, places the Jesse pool in a secondary class.

2. At present, the Bromide sand production is confined to Sec. 2, T. 1 N., R. 7 E. The sand is well developed, but thin, the average thickness being 12 feet. The sand grades into sandy limestone in other parts of the pool. Thirteen wells have been completed, two of which were non-commercial and are either plugged back or shut down. The lenticular character of the Bromide sand has made development very slow. Though additional production in the Bromide zone is expected, finding it will be expensive and hazardous. Initial bottom-hole pressures were the same as in the "Wilcox" sand.

The average initial production in the Bromide sand was 1,800 barrels. The estimated ultimate production is 1,680,000 barrels.

There are four wells in the Jesse pool producing from the Viola limestone only. The results from this formation have been disappointing; consequently, production from this zone is considered marginal. The average initial production from the Viola was 350 barrels.

3. Production from the Hunton limestone is also erratic, the initial production ranging from 63 to 3,480 barrels. The Hunton also has a gas cap in the crest of the structure; the approximate datum for the gas-oil contact is 3,000 feet below sea-level. The estimated ultimate production from the Hunton is 4 million barrels, from the present developed area. The Hunton production covers the widest area, but its extent can not be definitely determined at this time. It is considered, however, that the ultimate production may be more than doubled, depending, of course, on additional development which, in turn, is now dependent on the economic factor (Fig. 6).

A 10-acre spacing pattern was established by the Oklahoma Corporation Commission during the early development of the Jesse pool. Following the Hunton development, a 20-acre spacing pattern for the Hunton was adopted by agreement among the operators.

4. Production in the Pennsylvanian is confined to the Wapanucka and Atoka formations.

Three wells have been completed as gas wells in the Wapanucka sand, which is present at the top of the Wapanucka over most of the structure. Initial gas gauges were approximately 10 million cubic feet a day. No showings of oil have been observed in the sand. Cores from the Wapanucka limestone indicate that production can be expected in parts of the pool from the limestone.

Five wells have been completed in the "Gilcrease" sand in the Atoka formation, with an average initial production of 72 barrels a day.

Gas is also being produced from an upper Atoka sand in Francis, Province No. 2 in the NW. ¼, NW. ¼, NW. ¼, Sec. 2, T. 1 N., R. 7 E. This well was completed with an initial gauge of 7,500,000 cubic feet a day.

Many showings of oil and gas have been found in other sands in the Atoka formation, and production is expected to be developed from several horizons. These reservoir horizons are very lenticular, however, and the production will necessarily be spotted.

The production of the Jesse pool is prorated to 7 per cent of the potential, which is determined by flowing the well through 2½-inch tubing for a period of 6 hours. The last 4 hours are multiplied by 6 to compute the 24-hour potential. This method is applied to the Ordovician horizons only. The Hunton and Pennsylvanian production is limited to 100 barrels a day, regardless of the well's capacity to produce. The Ordovician is rated as a class B pool; the Hunton as class D.

On January 1, 1938, the Jesse pool had produced 1,704,164 barrels.

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VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1579-1587, 5 FIGS.

OLYMPIC POOL, HUGHES AND OKFUSKEE COUNTIES, OKLAHOMA[1]

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ABSTRACT

The Olympic pool is located in the Seminole district of south-central Oklahoma. The discovery well was completed in July, 1934. The principal producing horizon is a Senora sand of Pennsylvanian age. Minor production has been and is obtained from a Calvin sand and Cromwell sand both of Pennsylvanian age, and Hunton limestone of Siluro-Devonian age.

Production from the Senora formation is from a typical shore-line bar which extends 6¼ miles northeasterly, and has a maximum width of 1¼ miles. This lenticular sand member is named "Olympic sand." The average total depth of Olympic sand wells is 1,800 feet.

The total production of oil to January 2, 1938 is 7,530,575 barrels, which came from 326 wells. The average daily production for the week that ended, January 2, 1938, was 6,975 barrels. The gravity of the oil is 36° Bé.

LOCATION

The Olympic pool is in the east-central part of Oklahoma, just off the northeast edge of the Seminole uplift. It lies in parts of Ts. 9 and 10 N., Rs. 8 and 9 E., Hughes and Okfuskee counties. Its northeast end is 8 miles southwest of Okemah.

HISTORY

The Olympic Oil Company's McCaslin No. 1 in the SE. ¼, NW. ¼, NW. ¼ of Sec. 12, T. 9 N., R. 8 E., was the first oil well in the Olympic pool. It was completed in July, 1934, in the Cromwell sand at a total depth of 3,474 feet. The discovery Olympic sand well which started active development in the Olympic pool was Manahan's Dixon No. 1 in the NE. ¼, SW. ¼, NW. ¼ of Sec. 12, T. 9 N., R. 8 E. This well cored saturated oil sand in the Senora formation, tested the Cromwell sand, and drilled into the "Wilcox" sand of Ordovician age at a total depth of 4,279 feet. Water was encountered in the "Wilcox" sand, and the well was completed on July 17, 1935, as an oil well by plugging back and shooting the Olympic sand. To date 326 oil wells have been completed, and all but four of these derive their oil from the Olympic sand. The total yield from formations other than the Olympic sand has been an almost negligible portion of the total yield of the field; however, two wells produced from the Cromwell sand, one well produced from the Hunton "lime," and one well produced from a sand in the Calvin formation.

[1] Read by title before the Association at New Orleans, March 18, 1938. Manuscript received, June 30, 1938.

[2] Consulting geologist, 1306 Philtower Building.

SURFACE GEOLOGY

The rocks that occupy the surface in the Olympic pool belong to the Seminole conglomerate, and the Francis formation of Pennsylvanian age.[3] These formations are composed of interbedded sandstone and shale. The strata strike northeast-southwest and dip northwest at a low angle.

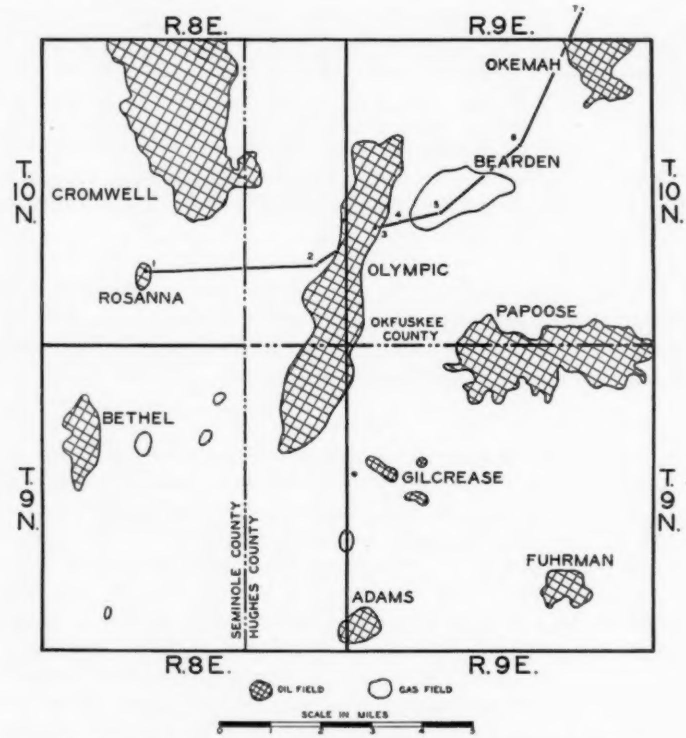

FIG. 1.—Index map showing oil and gas fields adjacent to Olympic pool and position of cross section illustrated in Figure 2.

SUBSURFACE GEOLOGY

The structure of the Olympic pool is shown on the two accompanying geological maps. One (Fig. 3) is contoured on the top of the Henryetta coal, the other (Fig. 4) on the producing Olympic sand. The Henryetta coal immediately overlies the Olympic sand. Although

[3] H. D. Miser, "Geologic Map of Oklahoma," *U. S. Geol. Survey* (1926).

the structure as shown by the two formations is essentially similar, the top of the Olympic sand shows more irregularities and exhibits typical "sand-bar" characteristics. Both structure maps show a northeast-southwest trending monocline dipping slightly north of west, but intercepted by a series of anticlines, domes, and anticlinal noses.

The structure on the Henryetta coal is a series of anticlines trending parallel to the normal strike, and an anticlinal nose trending southwest.

The structure on the Olympic sand is similar, with the addition of small closed domes which are due to the shape of the sand body. The dip is fairly flat or uniform across the top of the sand body but is abrupt off both the east and west sides.

OLYMPIC SAND

The Olympic sand is a local lenticular member of the Senora formation. The name "Olympic" is submitted to indicate its local identification. The sand has erratic occurrences regionally. Besides the Henryetta coal above, the "Senora lime" below the Olympic sand is a regional stratigraphic marker. Other sandstone members of the Senora formation are observed to be productive elsewhere, but none has become as important commercially as the Olympic sand.

The Henryetta coal, immediately overlying the Olympic sand, is an excellent marker both from a structural standpoint and for its use in anticipating the Olympic sand while drilling. The coal averages 2 feet in thickness, and is present in practically all the wells. There are places where this coal rests directly on top of the Olympic sand in the more central part of the pool although off the flanks the interval from the top of the coal to the top of the producing sand may be as much as 25 feet. Where the interval from the top of the coal to the top of the producing sand is sufficient the intervening formations in descending order are: (1) gray black shale, and (2) gray sandy shale (thinly laminated, light gray, very fine sand or silt and gray shale).

The "sandy shale" may or may not show oil saturation. In one well the "sandy shale" produced 350 barrels of oil initially. This is the only place known to the writer of production from this formation.

The top of the Olympic sand is ordinarily indicated by a gradational change from laminated sandy shale to massive or laminated sand containing oil and showing brown staining in the core or drill cuttings. The producing sand is typically fine, uniform-grained, micaceous massive sand containing varying amounts of coal and carbonaceous material. In producing oil wells the thickness of the

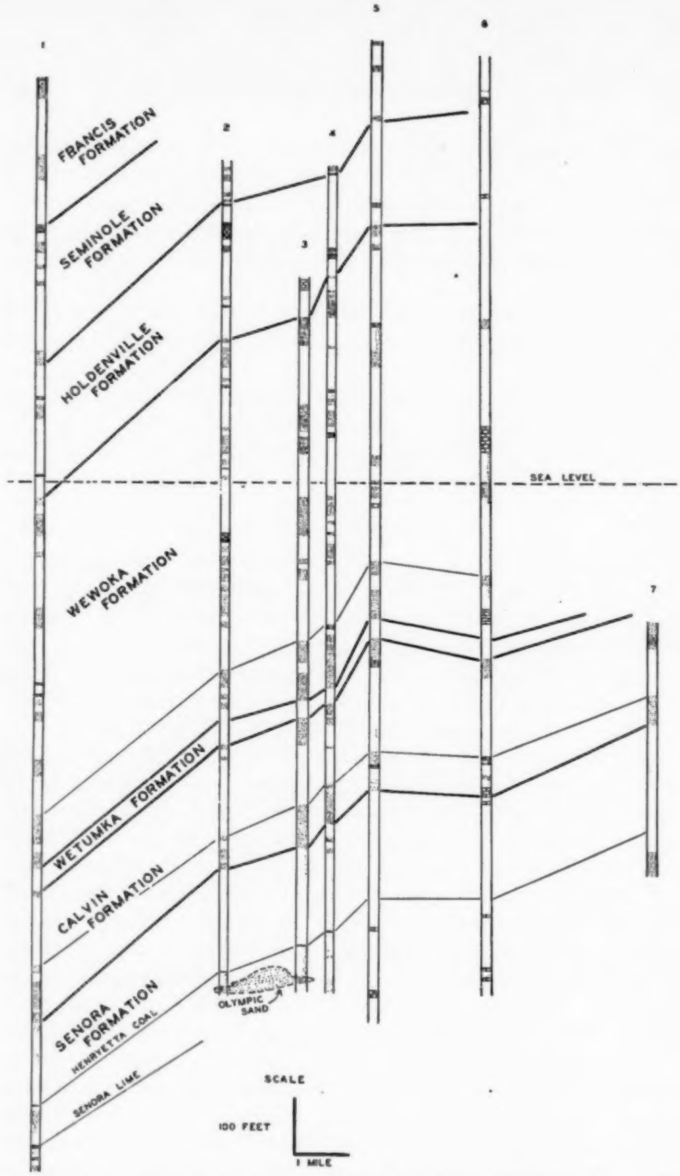

FIG. 2.—Cross section showing correlations of shallow Pennsylvanian formations in vicinity of Olympic pool and showing position of Olympic sand. Line of cross section is shown on Figure 1.

1. Sinclair-Prairie, Rosanna No. 1, NW. cor., SW. ¼, Sec. 28, T. 10 N., R. 8 E.
2. Kemrow, Simmer No. 1, SE. cor., NW. ¼, Sec. 25, T. 10 N., R. 8 E.
3. Chapman-Atlantic, Natchee No. 2, SW. ¼, NW. ¼, SE. ¼, Sec. 19, T. 10 N., R. 9 E.
4. Phillips, Wigton No. 1, NW. cor., SW. ¼, Sec. 20, T. 10 N., R. 9 E.
5. Burke-Greis, Montgomery No. 1, center, SE. ¼, NE. ¼, Sec. 20, T. 10 N., R. 9 E.
6. Kingwood, Carolina No. 1, NE. cor., NW. ¼, Sec. 15, T. 10 N., R. 9 E.
7. Grimes, Wind No. 6, center, east line, SW. ¼, NE. ¼, Sec. 35, T. 11 N., R. 9 E.

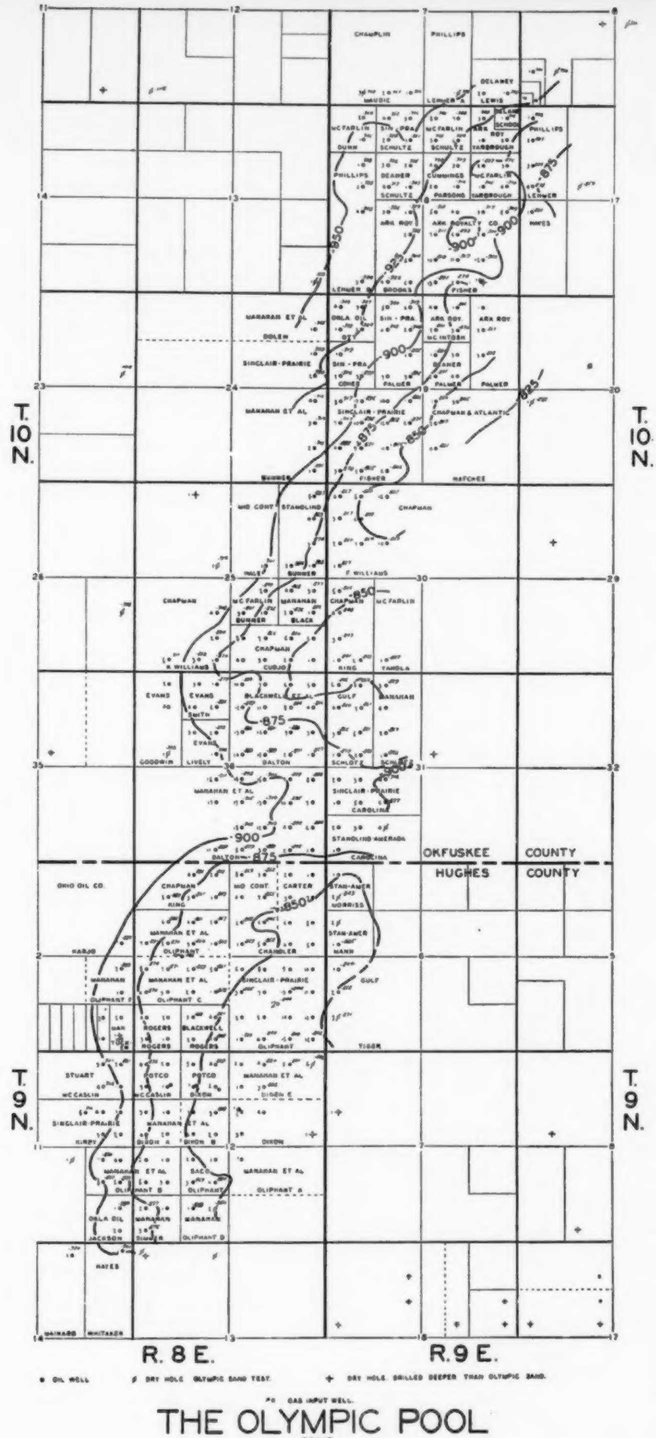

FIG. 3.—Structure of Olympic pool. Contours drawn on top of Henryetta coal.

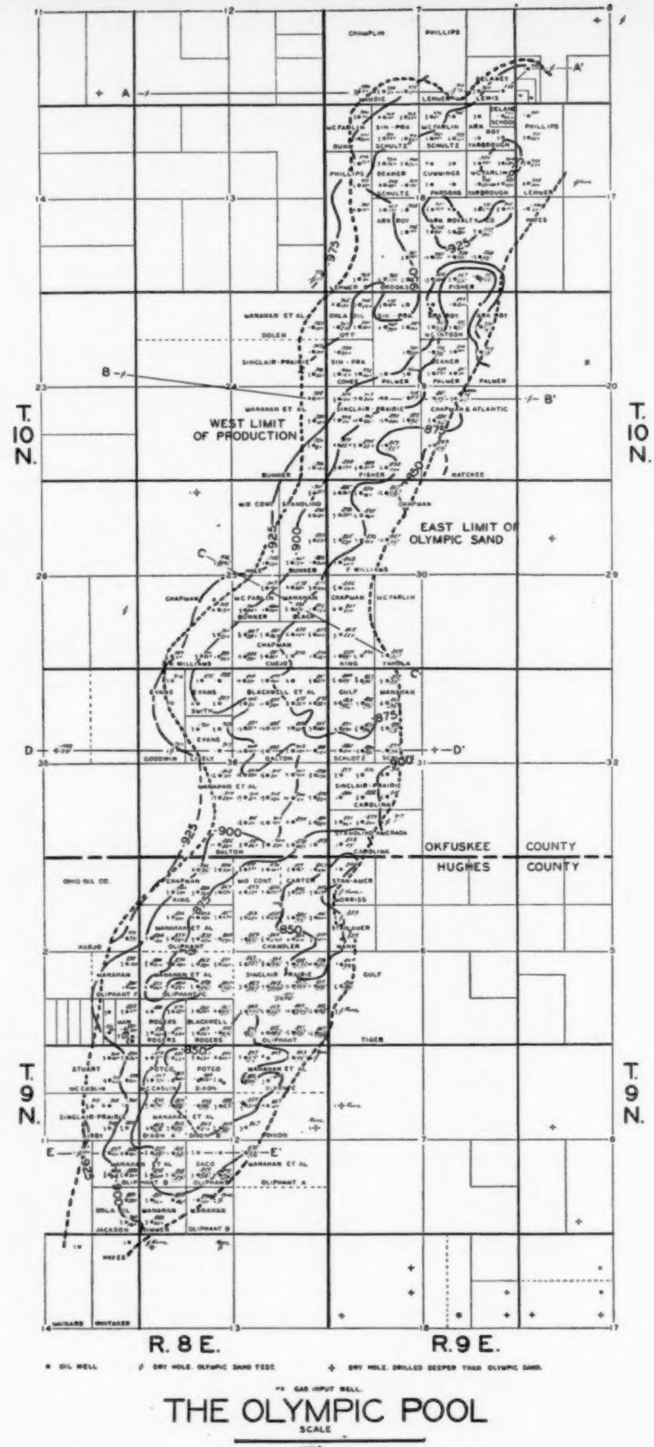

FIG. 4.—Structure of Olympic pool. Contours drawn on top of Olympic sand. Lines of cross sections shown are illustrated in Figure 5.

sand ranges from 17 feet on the east edge of the sand body to a maximum of 70 feet in the more central part of the pool. Some cores show the sand to be massive and others show sandy shale, silt, and mica laminations. Where observed the non-oil-bearing laminations within the sand body are not more than 4 inches thick. Horizontally the lithologic character at the producing horizon may change abruptly from sand to shale or sandy shale outside the producing sand body. There are several oil wells on the east side of the pool which are offset by dry holes.

In general, gas, oil, and water are separated in the sand body with water downdip, and oil and gas updip. The sand body originally contained gas in some of the higher wells on the east edge, and water is present on the west edge of the pool, although there is no well defined water line in the field. In the south part of the pool all wells drilled below 920 feet sub-sea-level in the sand produce some water, but in the north end of the field, most of the wells encounter the top of the producing sand below this elevation and produce oil in commercial quantities.

DRILLING METHODS

Practically all the wells are drilled with light, portable rotaries. In the earlier development standard practice was to core the top of the Olympic sand or core until saturation was encountered after drilling the Henryetta coal, and cement 7-inch O.D. casing at about the top of the Henryetta coal and drill in with cable tools using machines of the spudder type. Later practice was to cement casing at about the top of the coal and drill the oil sand with standard tools. The producing sand was shot in virtually all the wells.

PRODUCTION

On a potential test taken the latter part of 1936, and the first of 1937, seventy-eight wells produced an average of 375 barrels per 24 hours per well. All wells in the pool are now on the pump. Initial productions ranged from approximately 5 barrels on the pump to slightly in excess of 1,000 barrels flowing.

An average analysis of 12 cores taken in the top of the Olympic sand, and representing in no hole more than 15 feet of the top of the sand shows 25.9 per cent oil saturation and 18 per cent porosity. Oil saturation of the individual cores varies from 13.8 per cent to 38.3 per cent. The porosity varies from 11.9 per cent to 21.7 per cent.

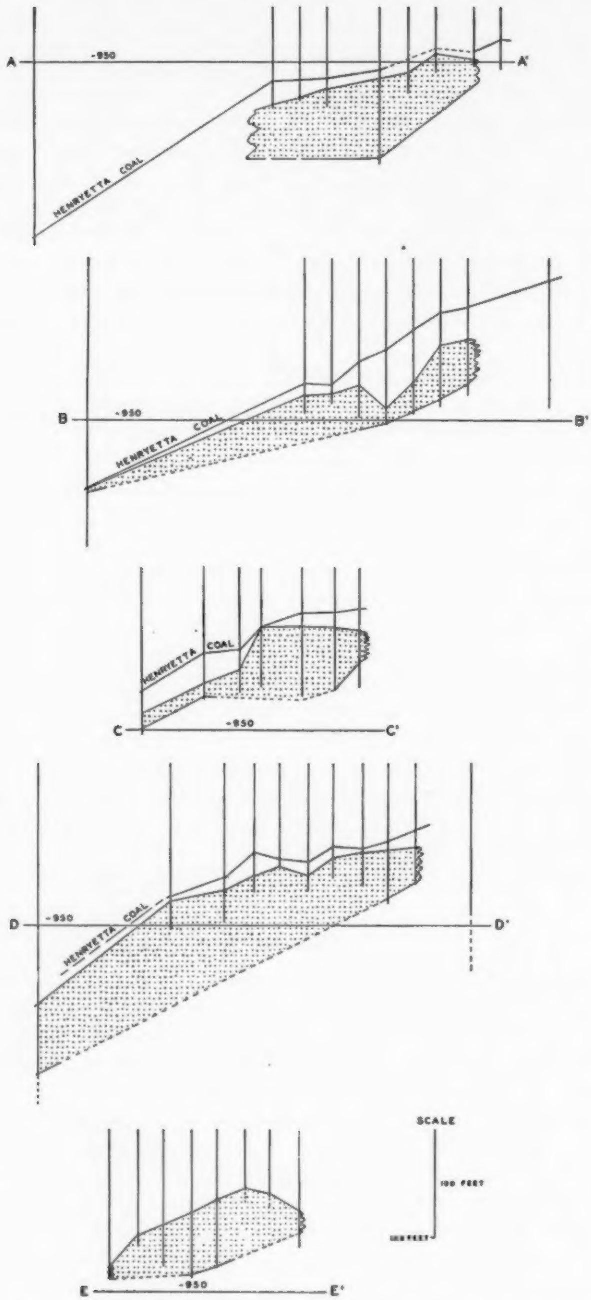

FIG. 5.—Cross sections through Olympic pool showing Olympic sand, producing sand body. Line of cross sections shown on Figure 4.

Three gas input wells have been drilled in the south end of the pool in Sec. 1, T. 9 N., R. 8 E., for the purpose of repressuring, and gas has been put back into the sand since about the middle of 1937. The results are unknown but the field should be ideal for repressuring. It is estimated that the pool will eventually recover 16–24 million barrels of oil from the Olympic sand.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO 11 (NOVEMBER, 1938), PP. 1588-1599, 4 FIGS.

STUDIES OF INSOLUBLE RESIDUES FROM "MISSISSIPPI LIME" OF CENTRAL KANSAS[1]

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ABSTRACT

Stratigraphic studies, facilitated by the use of insoluble residues, in central Kansas indicate the "Mississippi lime" may be subdivided into zones which closely correspond with members of the Boone limestone of Missouri. In typical pools of the included territory the oil is produced from one or both of two of the zones; and accumulation appears to be in many places in stratigraphic traps rather than simply on structural closures. The early warpings, observed in terms of overlaps at the position of the Burlington limestone, apparently were rejuvenated in Des Moines series (Pennsylvanian) time to form most of the important oil-field structures in central Kansas. Consequently the thickness changes depend on inter-zonal relations as well as more or less removal of upper beds of the "Mississippi lime" by pre-Pennsylvanian erosion.

INTRODUCTION

Geologists have been making progress for several decades toward a more complete solution to the "Mississippi lime" problem in the northern Mid-Continent. Only in recent years have well samples been available from which underground investigations could be made in central Kansas. This discussion deals briefly with studies conducted a few years ago when the "chat" or "Mississippi lime" became an important producing formation in the territory indicated by shading in Figure 1, and shown in more detail in Figure 2.[3]

The scope of the work was limited; consequently application of any ideas suggested thereby is limited to the territory studied. Especially is it realized that the problem of the "Mississippi lime" in Oklahoma and far western Kansas and eastern Colorado is decidedly different from that in central Kansas.

[1] Manuscript received, June 27, 1938. Read by title before the Association at New Orleans, March 18, 1938.

[2] Consulting geologist, Indian Territory Illuminating Oil Company.

[3] Coöperation of, and assistance from, several organizations and individuals are acknowledged, particularly E. A. Koester and N. H. Stearn. The Kansas Geological Society conducted its Seventh Annual Field Conference, September, 1933, in Missouri, Arkansas, and Oklahoma; typical Mississippian outcrops were examined, and A. W. Giles read "The Boone Formation," summing up his work in northern Arkansas. Also the work of G. M. Fowler and J. P. Lyden was published, "The Ore Deposits of the Tri-State District," *Amer. Inst. Min. Met. Eng. Tech. Pub. 446* (1932), followed by Fowler, Lyden, Gregory, and Agar, "Chertification in the Tri-State Mining District," *ibid., Tech. Pub. 532* (1934). And in November, 1935, the Joplin chapter, American Institute of Mining and Metallurgical Engineers, conducted the Tulsa Geological Society and the Tulsa chapter of the Institute through typical mine occurrences of ore bodies, chert, and limestone drifts at Fowler's "K" and "M" beds, respectively, at Picher, Oklahoma. Furthermore, the Missouri Bureau of Geology and Mines, under supervision of H. S. McQueen, had collected well samples and had correlated Mississippian formations of western Missouri, in connection with underground water-supply development. Also the older literature facilitated subsurface studies in central Kansas.

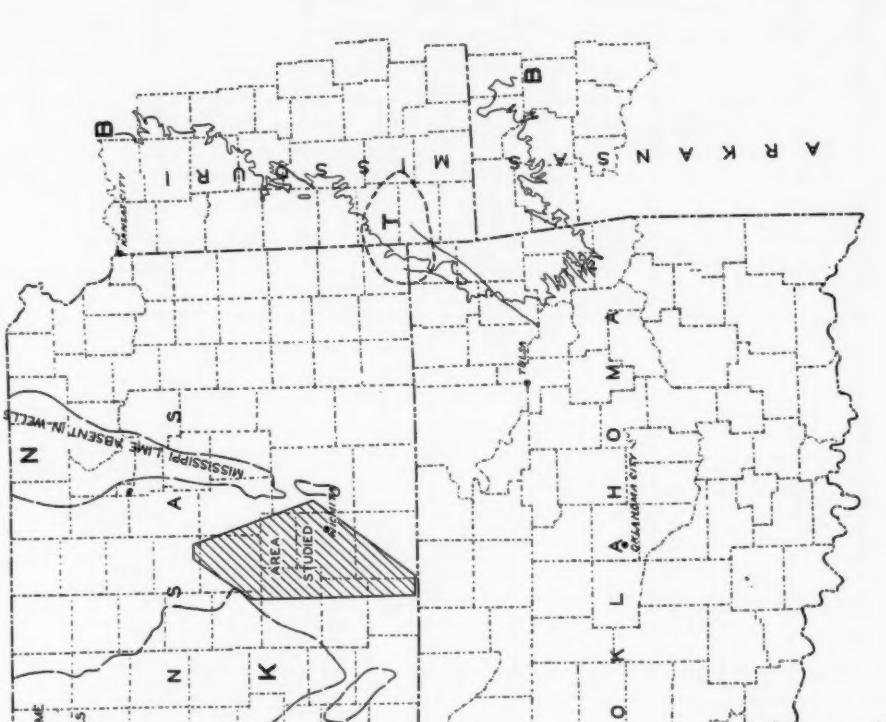

FIG. 1.—Index map, showing geographic relationships of area studied with *K*, Central Kansas buried uplift, *N*, Nemaha buried mountains, *BB*, outcrop of top of Boone limestone, and *T*, Tri-State zinc and lead district.

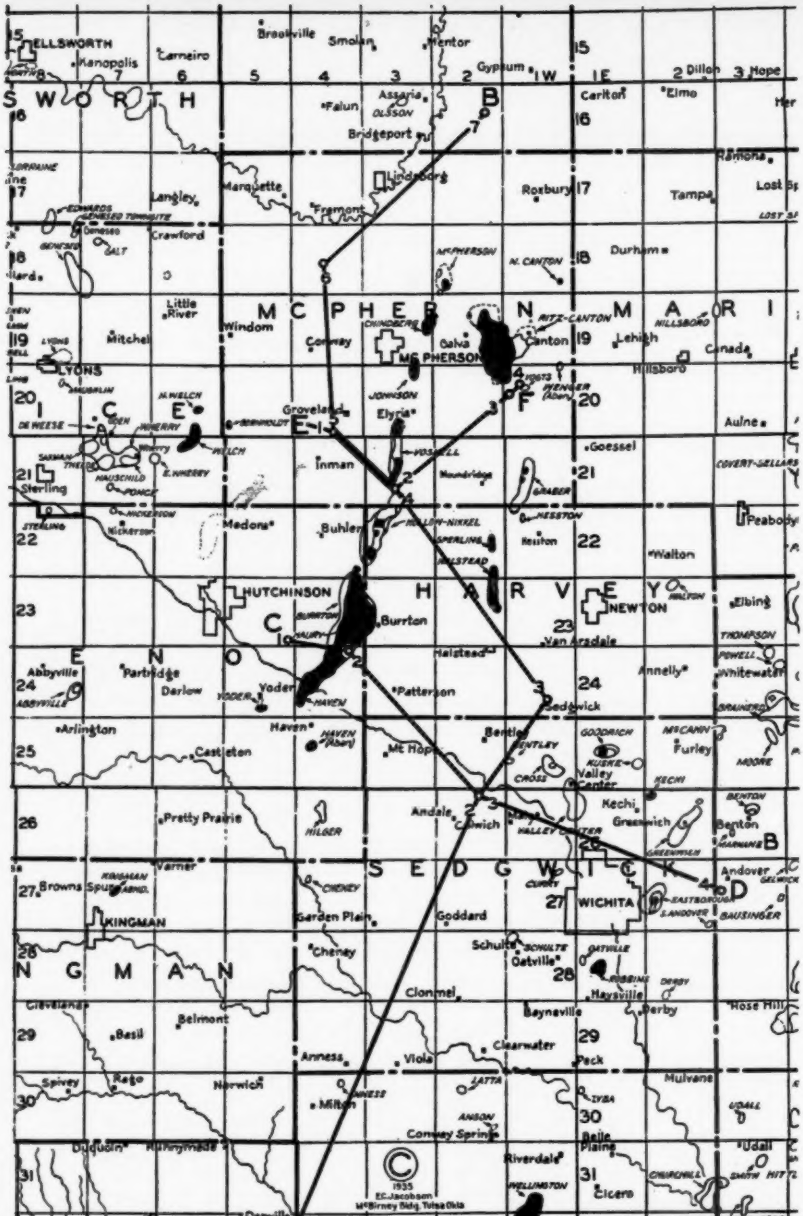

FIG. 2.—Oil and gas field nomenclature map, Ts. 15–35 S., Rs. 8 W.–3 E., Kansas, with fields producing from "Mississippi lime" indicated in solid black, and showing plans of stratigraphic cross sections *AB*, *CD*, and *EF*.

STRATIGRAPHY

The "Mississippi lime" in the territory shown in Figure 2 is found at depths just less than 3,000 feet in McPherson County, and at depths slightly more than 4,500 feet in Harper County. As illustrated in Figures 3 and 4, the Kinderhook shale is subjacent in all wells, with an apparently conformable contact. The Pennsylvanian sedimentary rocks rest unconformably on the upper surface of the "Mississippi lime"; or in the areas designated as the Central Kansas buried uplift and the Nemaha buried mountains, the Pennsylvanian rests on formations stratigraphically below the "Mississippi lime," due to erosion and subsequent overlap. The only outcrops occur in the southeastern corner of the state, bearing the name, Boone limestone (Fig. 1). The outcrop data were compiled from the geologic maps of Arkansas, Oklahoma, Kansas, and Missouri, published by the respective State surveys.

The term, "Mississippi lime," is borrowed from the oil fields. Associated closely is the word "chat," borrowed from the Tri-State mining district, where the tailings from the mills are known as "chat" piles; the word is probably a provincialism for chert. In central Kansas the "Mississippi lime" found in wells may be subdivided into zones or formations based on microlithology and the microcharacteristics of insoluble residues. In Figures 3 and 4, these zones are given alphabetical designations, following the custom of plane-table surveying where the subdivisions have not been traced continuously to type localities of formational outcrops. Striking similarities of lithologic character, thicknesses, and disconformities in the "Mississippi lime" of wells and the Boone limestone of Missouri prompted the indicated correlations of zones and outcrop formations in Figure 3.

Zone C is correlated conclusively with the Fern Glen formation. The original well samples comprise: drab, lithographic to dense limestone; gray to green dense shale; here and there some olive-drab waxy shale; crystalline tan to brown dolomite; and white, coarsely crystalline limestone with gray, speckled, vitreous chert. In residues[4] the material comprises: very shiny, yellow to golden pyrite and gray to black spongy pyrite; and yellowish to brown flaky clay or shale. In many places fossil fragments are seen, particularly a buff-colored,

[4] Insoluble residues were prepared according to the laboratory methods described by H. S. McQueen, "Insoluble Residues as a Guide to Stratigraphic Studies," *Missouri Bur. Mines and Geol. 56th Biennial Rept.* (1931), Appendix I. The chief advantage of McQueen's method is speed, without lack of dependability. In the samples where the material available from one well was extremely scarce, the writer chose to combine material from more than one envelope to make up a standard or half-size sample of McQueen's method. Care is required to avoid combining samples across important geologic contacts.

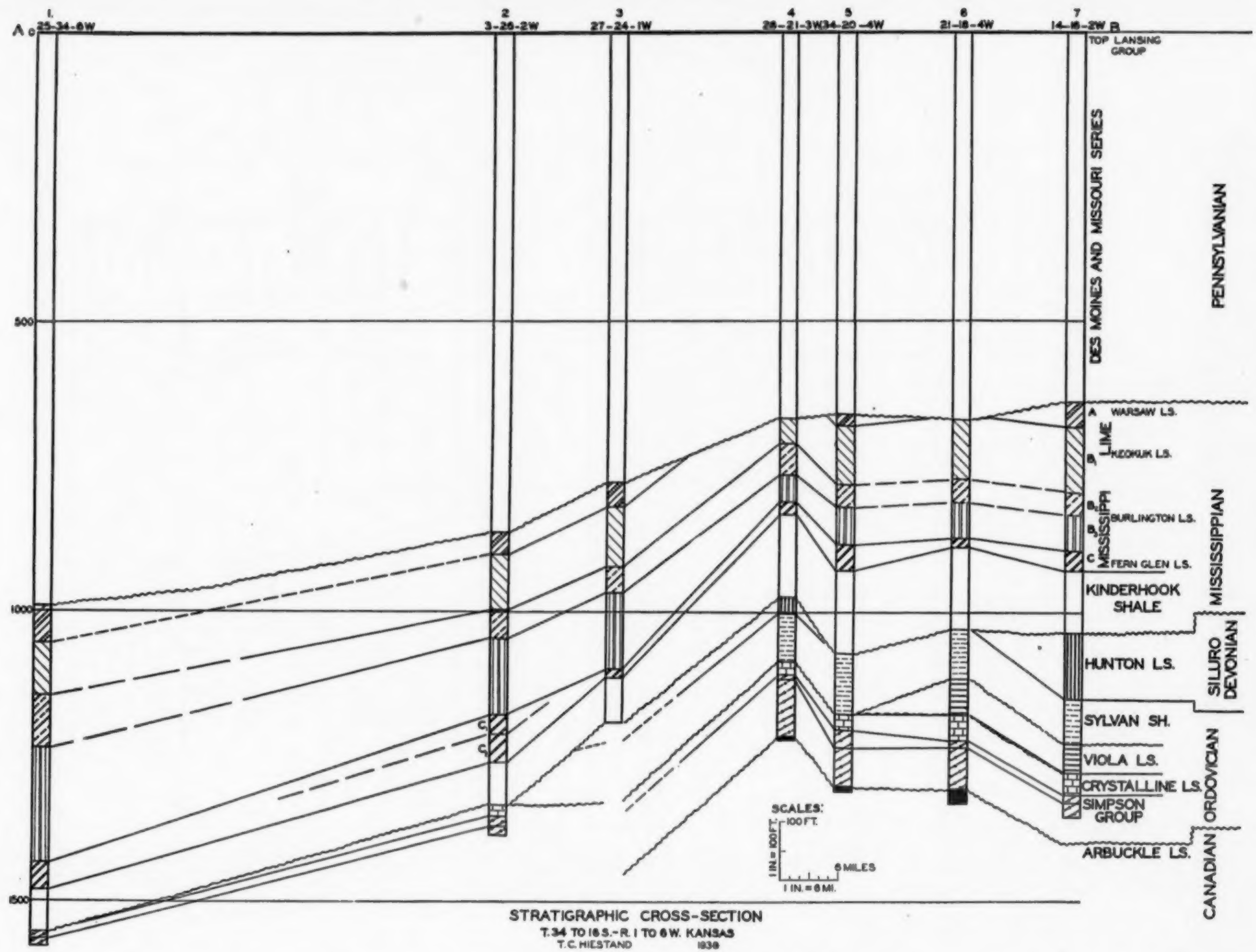

FIG. 3.—Stratigraphic cross section *AB* (T. 34 S., R. 6 W., to T. 16 S., R. 2 W.), arranged with top of Lansing group (Pennsylvanian) as datum plane, to show subdivisions of "Mississippi lime" and names of outcrop equivalents in Missouri.

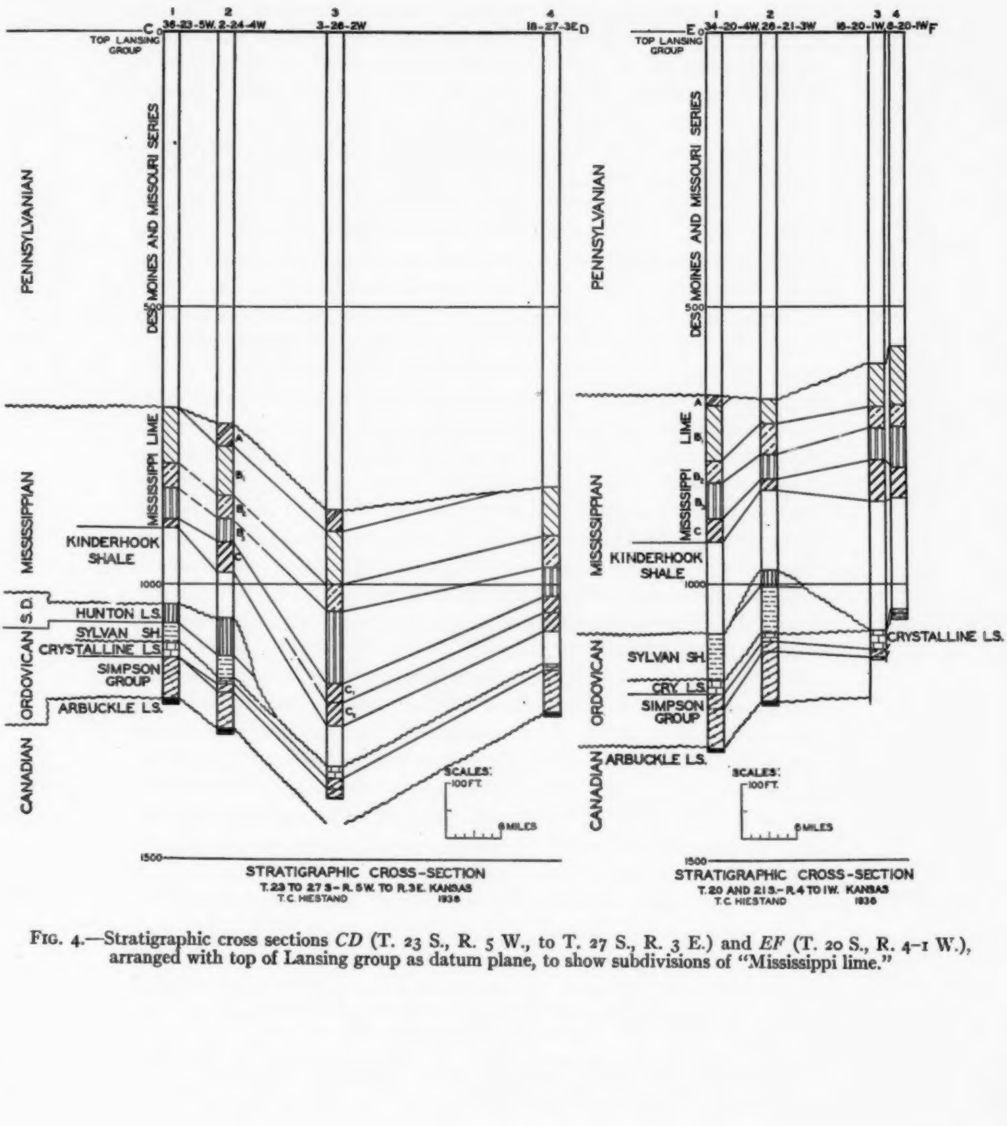

FIG. 4.—Stratigraphic cross sections *CD* (T. 23 S., R. 5 W., to T. 27 S., R. 3 E.) and *EF* (T. 20 S., R. 4–1 W.), arranged with top of Lansing group as datum plane, to show subdivisions of "Mississippi lime."

vermicular-like form. Rounded sand appears in variable amounts. And wherever the shale is non-flaky it is ordinarily finely dolocastic or buff, spongy to floury. The contact with the Kinderhook shale has been taken commonly as the base of the limestone from original samples, although some residues show the contact to be a few feet in underlying shale. The residue from Zone C is generally less than 50 per cent of the original by volume.

As shown in Figure 4, cross section *CD*, Zone C is divisible into C_1 and C_2 at localities 3 and 4. Such separation is not sharp enough to emphasize except to suggest Zone B may be disconformable with Zone C where C_1 is absent. The Zone C has been found to range in thickness from a minimum of less than 10 feet to a maximum of 160 feet. These correspond with the observations of Giles.[5]

Zone B, as shown in Figure 3, corresponds closely with the Burlington-Keokuk formations of Missouri, and may be classified further into three sub-zones. B_3 contains much smoky to pearl-gray, translucent to glassy chert. Part of the chert is knarly in residues, with fossil tracings and crinoid-stem fragments. The base commonly has pyrite, and in southernmost Kansas becomes conspicuously glauconitic near the contact with Zone C. This glauconite is very dark green and appears to be the material seen so commonly at the top of the Chattanooga shale in Oklahoma. Zone B_3 has thicknesses ranging from 50 to 200 feet. As shown in cross sections *AB* (Fig. 3) and *CD* (Fig. 4), this sub-zone thins toward the various upwarped or uptilted areas, and probably overlaps its basal beds in such places to produce an unconformable contact with Zone C.[6]

Zone B_2 may be said to be transitional in residue characteristics between B_3 and B_1, in the respect that the chert is translucent, vitreous, or non-vitreous. The base commonly contains pyrite, noticeable in residues. The contact with B_1 is in many places very sharply defined and marked by mineralization, particularly by sulphides and glauconite. The bed "M" of Fowler[7] is near this contact in the Tri-State mining district where the mineralization has been studied in mines.

Zone B_1 has the striking characteristics of the Keokuk formation.

[5] A. W. Giles, "The Boone Formation," *Seventh Annual Field Conference* (Kansas Geol. Soc., 1933).

[6] Overlaps in the Burlington limestone are described by L. R. Laudon, "Stratigraphy of Northern Extension of Burlington Limestone in Missouri and Iowa," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 9 (September, 1937), p. 1167.

[7] George M. Fowler, Joseph P. Lyden, F. E. Gregory, and William M. Agar, "Chertification in the Tri-State (Oklahoma-Kansas-Missouri) Mining District," *Amer. Inst. Min. Met. Eng. Tech. Pub. 532* (1934).

In the original sample material the tripolitic chert can not in all material be distinguished from the intermixed limestone and dolomite. In residues, however, is found a skeleton of porous, spongy, or smooth-edged surface of tripolitic to kaolinitic material. And vitreous chert is fairly common, containing delicate tracings which are fragments from bryozoan, crinoid, or other faunas. Pale to bright green, glauconitic material is generally conspicuous in residues. In many original samples, the sub-zone contains oölitic beds not unlike the Short Creek oölite mentioned by Fowler and others.[8] On uplifts such as the granite-ridge type of anticline (Fig. 2), T. 18 S., R. 2 W., to T. 24 S., R. 4 W., sub-zone B_1 may be found virtually a naturally formed insoluble residue where it rests unconformably beneath the Pennsylvanian, and probably has been subjected to leaching and weathering before burial. Such condition accordingly explains the porosity and permeability found in single wells which have recovered in excess of 300,000 barrels of oil from this sub-zone. And the removal of sub-zone B_1 in pre-Pennsylvanian time from the apex of a closure has been the writer's explanation as to why certain "high" wells have been non-productive in the "Mississippi lime." On the other hand the degree of development of porosity is not in every place greatest at the apex of a structural closure, which means in some places "high" wells are non-productive even though sub-zone B_1 extends over the closure, and the oil field is situated on the flanks of the closure. This habit likewise permits structural terraces and nosings to be effective traps as long as impervious beds exist updip in lieu of closure. The thickness of sub-zone B_1 remains in the proximity of 100 feet unless eroded in pre-Pennsylvanian time.

Zone A is tentatively correlated with the Warsaw limestone of Missouri. In original samples the material is white, calcitic to coarsely crystalline limestone, with traces here and there of glauconitic specks, and may be closely associated with the oölitic beds mentioned. In Figure 3, cross section *AB*, at localities 1 and 3, gray, brown-mottled, vitreous chert occurs that is strikingly similar to Warsaw limestone of northwestern Missouri. In residues the material is chiefly white, buff to brown, dense to porous or spongy, argillaceous skeleton, with some rounded sand, and pyrite at or near the base. The contact of Zones A and B is the big gas "pay" in T. 23 N., R. 4 W., Burrton field, Reno County.

Thus the "Mississippi lime" of wells in central Kansas is composed of a series of limestone formations which have not been traced by the writer to the outcrop but are found to have decided similarity

[8] Fowler *et al., op. cit.*

and are therefore tentatively correlated with the Boone limestone or Osage subseries[9] of Missouri and Arkansas. Traced from the center of the state southward to the Oklahoma boundary (as along the plan of the cross section *AB*, Fig. 2) the "Mississippi lime" of central Kansas reveals a change from gray and buff to a decided brown color; and with the color change studies of residues indicate an increase southward in argillaceous content.

CROSS SECTIONS

The cross sections (Figs. 3 and 4) are arranged with the top of the Missouri series or top of the Lansing group of the Pennsylvanian as the datum plane, in order to illustrate any coincidence of thickening and thinning of strata in the Lower Pennsylvanian and in the "Mississippi lime."

Cross section *AB* was laid out south-to-north and at right angles to the trend of the Central Kansas buried uplift (Fig. 1); *CD* and *EF* were laid out west-to-east to be at right angles to the granite-ridge trends of the Nemaha buried mountains (Fig. 1). Cross section plans are shown in Figure 2.

In Figure 3 a gradual northward thinning of the Pennsylvanian is indicated. Where not locally affected by pre-Pennsylvanian erosion, Zones A, B_1, and B_2 remain relatively constant throughout. But sub-zone B_3 is four times as thick at locality 1 as at 4, where the cross section traverses the Voshell granite ridge; and this sub-zone is three times as thick at locality 1 as at 5, 6, and 7.

Likewise in cross section *CD* (Fig. 4) sub-zone B_3 is three times as thick at locality 3 as at 2, where the granite ridge is traversed; and is more than twice as thick at 3 as at 4. The Zones A, B_1, and B_2 retain their normal thicknesses. The locality 3 is in a well developed structural syncline between buried folds of the granite-ridge type. These illustrations suggest early warpings in Burlington limestone time were to be developed to sharp definition in the folding of early Pennsylvanian (Des Moines series) time.

In Figure 4, cross section *EF*, differential pre-Pennsylvanian erosion of the upper beds of the "Mississippi lime" is illustrated. From locality 1 to 2, the erosion is of greater moment than changes of thickness within sub-zone B_3. And from locality 2 to 3 and 4 the Lower Pennsylvanian thins, whereas the thickness of the "Mississippi lime" increases. The cross section exhibits erratic thicknesses of Zone C.

All the cross sections illustrate the lack of coincidence of any

[9] R. C. Moore, "Early Mississippian Formations in Missouri," *Missouri Bur. Geol. and Mines*, Vol. 21, 2nd Ser. (1928), p. 282, Fig. 2; also L. R. Laudon, *op. cit.*, p. 1158.

systems of the warping between pre-Pennsylvanian and pre-Mississippian folding. Cross section *AB* extends from the pre-Mississippian Salina basin at locality 7, southward to the crest of the Chautauqua arch near locality 1, and therefore clearly depicts the overlap of the Kinderhook shale across Siluro-Devonian and Ordovician strata. But in this cross section contrariwise, the sub-zone B_3 and the Pennsylvanian overlap northward.

Therefore it may be said the studies indicate that the Kinderhook shale and the Fern Glen limestone were deposited during a state of only slight crustal warping; that this stage succeeded one of important warpings in Upper Devonian and pre-Mississippian time. During Burlington limestone time noticeable warpings were initiated which elevated areas that had been depressed in pre-Mississippian time, and which also depressed areas that had been elevated in pre-Mississippian time. Local anticlinal features were initiated with trends north-south rather than east-west in alignment. And such processes of warping and folding, although remaining dormant during deposition of part of the Mississippian above the Burlington, were rejuvenated in early Pennsylvanian (Des Moines series) time to extreme definition into large regional features (central Kansas buried uplift and Nemaha buried mountains, Fig. 1), as well as local granite-ridge folds like those in McPherson, Harvey, and Reno counties, shown in Figure 2.

When regional studies of Kansas were conducted[10] the writer found that the Missouri series was deposited during a stage of comparative crustal stability, which succeeded the stage of instability just mentioned. For this reason the top of the Missouri series or the top of the Lansing group constitutes a useful stratigraphic datum for the cross sections.

From tracing the subdivisions of the "Mississippi lime" to where overlap by Pennsylvanian beds is complete, the writer considers the absence of the "Mississippi lime" in wells in areas so designated (Fig. 1) to be due chiefly to pre-Pennsylvanian erosion. The scope of the work was too limited to make the statement general, however. The normal thickness of the "Mississippi lime" in central Kansas, where Zones A, B, and C, are present, is approximately 300 feet.

TOP OF "MISSISSIPPI LIME" DETERMINATIONS

Either rotary or standard tools commonly recover samples from which the contact of the variegated shale beds of the Pennsylvanian on the "Mississippi lime" can be approximated but not determined

[10] T. C. Hiestand, "Regional Investigations, Oklahoma and Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 7 (July, 1935), pp. 962 and 964.

specifically. The shale and clay "cave" or ravel until it becomes practically necessary to examine the samples and determine the zones of the "Mississippi lime" first, and then, "running the samples backward," choose the last of the material belonging to the uppermost zone which appears to be in place. Reworked material derived from the Mississippian and found in the Lower Pennsylvanian is commonly stained with oxides; in residues these oxides have been reduced. Caverns or sinks occur in the "Mississippi lime" and are in most places filled with Pennsylvanian clay or shale, but such fill can be distinguished as a rule from beds deposited on a plane surface. Evidence of a sink is shown in Figure 4, cross section *EF*, locality 4. Many sinks filled with clay or shale may be seen in Boone limestone quarries of western Missouri.

PRODUCING ZONES OF THE "MISSISSIPPI LIME"

In most of the fields producing from the "Mississippi lime," wells have been drilled through the formation, and these allow a study of the zones present in such localities. It almost becomes the rule that some of the wells located highest on the structure are non-productive. In the Johnson (Ts. 19, 20 S., R. 3 W.) and the Voshell (Ts. 20, 21 S., R. 3 W.) pools, the Zones A and B_1 have been removed by pre-Pennsylvanian erosion from the tops of the closures. Irregular casing and penetration practices in parts of the Hollow pool (T. 22 S., R. 3 W.) permitted a premature encroachment of water. In parts of the Burrton pool (T. 23 S., R. 4 W.) the water was not adjusted to structure, flanking local closures on top of Zone A, and causing some "inside" wells to be commercial failures. In the Welch pool (Ts. 20, 21 S., R. 6 W.) a stratigraphic trap is considered to be present with decrease of porosity laterally and updip, combined with a structural nosing. In the Robbins pool (T. 28 S., R. 1 E.) the porosity in Zone B_1 decreases over part of the apex of the closure, causing accumulation on the south and east flanks. Zones A and B_1 have the porosity necessary for commercial production in these fields; however, Zone A is in many places absent. Production at the Voshell and Burrton pools extends comparatively long distances down the southward anticlinal plunge, and only a short distance down the north closing dips. In none of the fields mentioned has any oil been known to have been produced commercially from Pennsylvanian conglomerate.[11] Most of the wells acidized have responded with large increases in rates of production; and acidization appears to be almost necessary for wells completed with rotary tools.

[11] The conglomerate produces oil in commercial quantities in parts of Rice and Russell counties.

CONCLUSIONS

Stratigraphic studies indicate all the zones or subdivisions vary too greatly in thickness to permit estimates to the base of the "Mississippi lime" in drilling wells, even after reaching the top of Zone C. And due to erratic occurrence of porosity in Zones A and B_1, or their removal by pre-Pennsylvanian erosion, a single test well, although situated at the apex of a closure, can not in every place be sufficient to prove or condemn a prospective area for production from the "Mississippi lime."

Implications arise with respect to origin, deposition, and distribution of chert from the finding that distinctive chert zones of the Boone limestone of Missouri extend for distances of 150–200 miles toward the west into central Kansas.

Subdividing the "Mississippi lime" of all parts of Kansas and adjacent areas should furnish needed data to make more complete interpretations of the history of the Central Kansas buried uplift and other important structural features.

DISCUSSION

MAX LITTLEFIELD, Tulsa, Oklahoma (written discussion received, June 27, 1938). The gravimetric method offers some advantages in that samples of different sizes are reduced to common terms; that specific gravities have a more direct relation to mineralogical properties than does volume; and that the residue percentage is not a function of the size grades of the gross sample.

Volumetric residues are more economical for work involving differentiation of formations or sizable members such as those described by Mr. Hiestand. Gravimetric data are of help in detailed zoning within a formation where both qualitative and quantitative sequences of repeated criteria must be used.

If correlation can be made solely on the bases of qualitative criteria peculiar to somewhat limited horizons, residues run on type well sections may serve as control. After the criteria are established, careful examination of the gross samples from near-by sections will reveal at least 75 per cent of the criteria, which is generally enough for generalized correlation.

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GEOLOGICAL NOTES

NAVARRO CROSSING FIELD, HOUSTON COUNTY, TEXAS[1]

E. B. WILSON[2]
Tyler, Texas

The Navarro Crossing field is located in northwest Houston County, Texas, approximately 1 mile east of the Trinity River, 4½ miles south of the north line of Houston County, and 12½ miles south, 80° west of the town of Grapeland. Although considerable leasing had been done previously as a result of surface work, real interest in the area developed after the discovery in October, 1933, of the Long Lake field, located 13 miles northwest in Anderson County. During 1933, the area was core drilled and was later surveyed by reflection seismograph, which indicated the presence of favorable structure. In 1936, Walter Goldston drilled B. W. Burns No. 1 in the Juan La Reviere Survey. This test was located about 8,500 feet southeast of the present production and had good showings of gas and oil in the Woodbine sand, but was abandoned as a dry hole.

On April 24, 1938, the Humble Oil and Refining Company's H. H. Dailey No. 1, the discovery well, was completed at a total depth of 5,920 feet, flowing 296 barrels of oil per day, with a gas-oil ratio of 4,420 to 1, through a ¼-inch tubing choke, casing being perforated in the Woodbine sand between depths of 5,891 and 5,893 feet. The oil is greenish brown in color, has a paraffine base, and a gravity of 35° A.P.I. Pressures were 1,800 pounds on tubing and 2,200 pounds on casing. Top of the Woodbine formation was encountered at 5,786 (−5,522) feet. The gas-oil contact was found at 5,888 (−5,624) feet and the oil-water contact at approximately 5,900 (−5,636) feet, giving a maximum oil-sand thickness of 12 feet. Above the oil sand there are two gas sands, having a total thickness of at least 30 feet.

To date, three other producing wells and one dry hole have been completed. Humble Oil and Refining Company's Burns Heirs No. 1 and Sun Oil Company's Dailey No. 1, direct and diagonal offsets, respectively, to the west and northwest, have been completed as oil wells, with sand data comparable to the discovery well. Humble Oil and Refining Company's Dailey and Taylor No. 1, approximately 5,000 feet southwest of the discovery well, was 47 feet lower

[1] Manuscript received, August 15, 1938.

[2] Sun Oil Company.

on top of the Woodbine and was completed as a gas well in the upper sands after showing salt water in the lower sand. Humble Oil and Refining Company's C. C. Hill No. 1, located 6,700 feet east and slightly north of the discovery well, was 66 feet lower on top of the Woodbine. The uppermost gas sand was absent in this well, and the first good sand, encountered at 5,920 feet, is probably the equivalent of the second gas sand of the discovery well. This sand showed salt water, as it was about 20 feet below the water level as found in the other wells, and the well was abandoned at a depth of 5,935 feet.

The structure of the area appears to be an anticlinal fold trending approximately northwest-southeast. As there are three distinct sand zones capable of producing, it is likely that with additional development the field will be spotted with oil and gas wells, depending on the depth at which the sands are encountered with reference to the water level and the gas-oil contact. All of the oil wells completed to date produce salt water with the oil, the percentage varying from 10 to 35 per cent. The gas is classed as dry.

At present the field has no pipe-line connections.

CEDAR POINT FIELD, CHAMBERS COUNTY, TEXAS[1]

JOSEPH M. WILSON[2]
Houston, Texas

Evidence of structure in the Cedar Point area in Galveston Bay was first indicated by torsion-balance work carried on by means of floating equipment. The prospect was then worked with the reflection seismograph, by the use of both the dip and continuous profile methods, and a sharply dipping faulted structure was found, which appears to be of the deep-seated salt-dome type. As the result of this work, the location for the discovery well was made.

On February 12, 1938, the Standard Oil Company of Texas and the Salt Dome Oil Corporation completed their State No. 1-118 in the Frio sand as the first test and the discovery well of the Cedar Point field. The Frio was found at 5,956 feet and the well was cored to a total depth of 6,030 feet. The well was completed through screen and liner from the entire 74 feet of Frio section, more than half of which was oil sand in several zones interbedded with streaks of shale. The initial production was 642 barrels of 36.2° gravity oil in 24 hours through a ¼-inch choke, with a tubing pressure of 990 pounds and

[1] Manuscript received, August 23, 1938.

[2] The Salt Dome Oil Corporation.

with the casing sealed. Subsequently, the Standard Oil Company of Texas and the Salt Dome Oil Corporation completed their State No. 1-119 and the Humble Oil and Refining Company completed its State No. 1 and State No. 2-95, as similar wells in the Frio sand. The Humble Oil and Refining Company's State No. 3-95, the deepest well in the field, is dry and abandoned at a total depth of 6,528 feet, still in the Frio sand.

On August 9, 1938, the Standard Oil Company of Texas and the Salt Dome Oil Corporation completed their State No. 1-94 in Miocene sand, cored from 4,414 to 4,430 feet. Its initial production was 263 barrels of 28.4° gravity oil on a ¼-inch choke with tubing pressure of 260 pounds and with the casing sealed. This is the first and only Miocene producer in the field to date. The sand from which it was completed was indicated by an electrical survey.

This field is unique in that it is the first on the Texas Coast in the water-covered bay areas. The discovery well, which is 5 miles southeast of the old Goose Creek field, is 1 mile from shore. The water is 6 feet deep at mean low tide, and is very rough during a strong wind. A fleet of boats is maintained to carry on operations. Oil from the Standard Oil Company of Texas and the Salt Dome Oil Corporation wells is flowed direct into barges for delivery to the purchaser, and oil from the Humble Oil and Refining Company wells is flowed through an underwater pipe line to stock tanks on shore.

FRIENDSWOOD FIELD, HARRIS COUNTY, TEXAS[1]

OLIN G. BELL[2]
Houston, Texas

The Friendswood field of southern Harris County, Texas, one of the important new fields of the Texas Gulf Coast, was opened on July 10, 1937, by the Humble Oil and Refining Company's J. J. Settegast No. 1, in the northeastern edge of the Perry and Austin Survey.

This discovery well had an initial flow of 640 barrels per day from a sand in the upper part of the Frio from 5,811 to 6,014 feet.

Subsequent development has shown a gas cap over a part of the field with the gas-oil contact at subsea 5,645 and the oil-water contact at subsea 6,040 feet.

[1] Published by permission of the Humble Oil and Refining Company. Manuscript received, September 1, 1938.

[2] Production geologist, Humble Oil and Refining Company.

This field is complicated by faulting, as is common in deep-seated domal structures of the Gulf Coast.

At this time (August 26) seventy-one oil wells have been completed, of which four are producing some water. Nine dry holes have been drilled around the edge of the field since discovery, but the productive limits have not been defined.

Credit for the discovery goes jointly to subsurface geology and geophysics.

DISCOVERY OF OIL IN BODCAW SAND, COTTON VALLEY FIELD, WEBSTER PARISH, LOUISIANA[1]

A. A. HOLSTON[2]
Shreveport, Louisiana

The Cotton Valley field, Ts. 20 and 21 N., R. 10 W., Webster Parish, Louisiana, was considered to be a gas and "distillate" field in the Cotton Valley formation, until the Stanolind Oil and Gas Company's Pardee Lumber Company No. 1, center SW., NE., Sec. 36, T. 21 N., R. 10 W., on the southeast flank of the Cotton Valley structure and the lowest well structurally to that date, was completed during May, 1938, as an oil well in the Bodcaw sand. Forty-one wells had been completed, with no dry holes, in the Bodcaw sand. Average production was 400 barrels of colorless 62° gravity fluid per day, through $\frac{1}{2}$-inch tubing choke and with an average gas-fluid ratio of 12,500. The Stanolind's Pardee No. 1 had the Bodcaw section as gas and "distillate" sand from 8,611 to 8,630 feet, sandy shale with oil stain from 8,604 to 8,611 feet, and oil sand from 8,611 to 8,630 feet. With the total depth of 8,642 feet in shale, $5\frac{1}{2}$-inch casing was cemented at 8,607 feet and the well completed, flowing 392 barrels of oil in $11\frac{1}{2}$ hours through $\frac{1}{4}$-inch tubing choke. Gas-oil ratio was 560. The oil has a paraffine base, a gravity of 41°, a high wax content, and is green in color.

Since completion of the Stanolind's Pardee No. 1, a test located on the south flank of Cotton Valley has been completed as an oil well in a sand in the Cotton Valley formation, above the Bodcaw, and higher structurally than the Stanolind's Pardee No. 1. Also a test located on the northwest flank of the structure and only slightly lower than the Stanolind's Pardee No. 1 has tested water from the Bodcaw sand, indicating the oil zone is probably a narrow rim around this structure.

[1] Manuscript received, September 12, 1938.

[2] Stanolind Oil and Gas Company.

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VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1604-1605

DISCUSSION

POWDER WASH FIELD, COLORADO, WATER ANALYSIS

COMMENT BY L. C. CASE[1]
Tulsa, Oklahoma

CORRECTION BY W. T. NIGHTINGALE[2]
Rock Springs, Wyoming

L. C. CASE: In the article by W. T. Nightingale, "Petroleum and Natural Gas in Non-Marine Sediments of Powder Wash Field in Northwest Colorado," in the August *Bulletin*, the water analysis at the top of page 1038 is evidently incorrect. Water can not have both primary alkalinity and secondary salinity, since the two are incompatible. This is probably a typographical error. However, something else seems to be wrong with the analysis. The positive reacting value is appreciably more than the total negative reacting value. Evidently some negative radical, probably CO_3, has been omitted.

The sample was evidently found by analysis to have 31 parts per million of *OH*, or hydroxide. Caustic compounds are very unstable when in contact with a great many components of sedimentary rocks. Also, hydroxide is reactive with organic compounds. It is stated that this is an oil-bearing zone. I believe the statement to be true that waters having free causticity have never been found in nature. I have found such occurrences in water samples taken during, or immediately after, drilling out the cement in a well. The cause of the hydroxide is evidently due, in these cases, to intimate mingling of the water and cement. Water samples thus found to be contaminated with cement were found to have no magnesium, this element having been completely thrown down as the hydroxide. The relationship appears to be applicable to the analysis in question.

W. T. NIGHTINGALE: Owing to some unexplainable error in transcription from the original manuscript parts of two different water analyses were copied as one and the CO_3 radical was left out. The correct analysis for the water recovered from the 5,218-foot level at Powder Wash is as follows.

Sample IV—5,218-foot Level, Petroleum Zone

Total parts per million 16,379 (calculated)

Radicals	(Na & K)	(Ca)	(SO_4)	(Cl)	(CO_3)	(OH)
Parts per million	5,838	573	137	9,516	284	31
Reacting value	253.96	28.60	2.85	268.42	9.43	1.82
Value in percentage	44.94	5.06	0.50	47.50	1.68	0.32

Primary salinity	89.88%
Secondary salinity	6.12%
Primary alkalinity	0.00%
Secondary alkalinity	4.00%
Chloride salinity	98.95%
Sulphate salinity	2.48%

[1] Gulf Oil Corporation.

[2] Mountain Fuel Supply Company.

I am also in agreement with Mr. Case's explanation of the *OH* radical in the analysis under consideration. Cement contamination is the reasonable explanation with regard to the chemical peculiarities of this water sample which was secured by bailer after the casing had been set and cemented on the sand. The surprising feature is the persistency of cement contamination in the water even after several days of bailing from the sand.

GEOLOGICAL SUCCESSION OF CENTRAL VENEZUELA (CORRECTION)

In the article, "Geological Succession of Central Venezuela," by M. Kamen Kaye, in the September *Bulletin*, line 2 from bottom of page 1225, the word "southwest" should be "*southeast*," so that the sentence reads, "In a simple manner, the Venezuelan Andes may be viewed as a vertical uplift from whose main plug sediments are thrust off both northwest and southeast."

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VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1606-1612

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available to members and associates.

THE LAND OF SHEBA, BY H. ST: J. B. PHILBY

REVIEW BY C. H. DANE[1]
Washington, D. C.

"The Land of Sheba," by H. St. J. B. Philby. *The Geographical Journal* (London), Vol. 92, No. 1 (July, 1938), pp. 1–21; 6 pls. of photographs, folding map. Vol. 92, No. 2 (August, 1938), pp. 107–32; 8 pls. of photographs, folding map.

Of general interest as a record of exploration and reconnaissance mapping of a large part of southwestern Arabia hitherto unexplored and largely unvisited by modern Europeans, this paper is of special interest to geologists because it records the existence of apparently intrusive salt masses in southwestern Arabia. The existence of salt deposits in this region has been previously recorded on hearsay evidence,[2] but evidence of their nature as salt plugs has not heretofore been given. Two paragraphs only of the text are of particular interest in this connection and may be quoted.

> The next morning I visited the salt mine of Milh Mughaira. The mine itself is a cavity extending to a depth of 30 feet, with a superficial area of about 50 feet each way. The rock strata lying above the salt and under the silt covering the ridge are almost vertical and somewhat contorted. They were of black coloring, suggesting oil or bitumen, rather flaky and soft. I descended into the mine by a steep slope from the opening. The salt wall is streaked with the mark of picks. Holes are bored in the salt to receive sticks of dynamite, whose explosion loosens a considerable mass of the rock. The workmen then dig the stuff out with their picks and gather it into heaps for filling into skin bags to be transported to Hadhramaut and even to Najran.
>
> It is an interesting fact that there is a whole series of salt mines, lying roughly from west to east, extending from near Baihan and Marib to beyond Shabwa [Sheba]. Each of them is located in an isolated "island" of low hills, similar to those of Shabwa, at a little distance eastward of the plateau escarpment, whose strata of limestone overlying a base of sandstone are quite horizontal and appear to have remained undisturbed by whatever movement took place along their front.

The distance from west to east in which the salt mines occur is about 70 miles.

The map that accompanies Part 2 has an inset sketch topographic map of the ruins of Shabwa on a scale of 1:20,000 which displays a central depression in which the salt mines are situated and an encircling ring of hills, the inner depression having a diameter of perhaps 2,500 feet, the topography thus suggesting the salt-plug type.

In the discussion of the paper P. M. Game cites the occurrence in Philby's collections at three localities, in a north-south line 20 miles long through Shabwa, of oil shales and bituminous limestones cropping out around the margin of the salt masses and presumably originally overlying the salt. The

[1] Geologist, United States Geological Survey. Manuscript received, September 3, 1938.

[2] George Martin Lees, "The Geology and Tectonics of Oman and of Parts of Southeastern Arabia," *Quar. Jour. Geol. Soc. London*, Vol. 84, Pt. 4 (December, 1928), p. 590.

surface rocks in the vicinity of Shabwa are shown from fossil collections to be of Eocene age.

In Lees' paper cited in the first paragraph the suggestion is made that the salt series that forms the plugs of southern Persia[3] extended for some distance southwestward into Arabia, governed by a predominant strike of the old pre-Cambrian rocks of Arabia from north and south to northeast and southwest. It seems not improbable that the salt masses of southern Arabia are developed from an extension of the salt series of Persia and the Persian Gulf. If so, the belt of salt-plug intrusion may extend between the two areas across the intervening Rub al Khali desert, one of the most extensive areas in the world that is absolutely unknown geographically and geologically.

[3] John Vernon Harrison, "The Geology of Some Salt Plugs in Laristan (Southern Persia)," *Quar. Jour. Geol. Soc. London*, Vol. 86, Pt. 4 (December, 1930), pp. 463–520. Reviewed by D. C. Barton in *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 6 (June, 1931), pp. 713–14.

PRACTICAL SEISMOLOGY AND SEISMIC PROSPECTING, BY L. DON LEET

REVIEW BY DONALD C. BARTON[1]
Houston, Texas

Practical Seismology and Seismic Prospecting, by L. Don Leet. 430 pp., 185 illus. Royal 8vo. D. Appleton-Century Company, New York and London (1938). Price, $6.00.

The contents of the textbook comprise: I. Cause and distribution of earthquakes; II. Elasticity and elastic waves, propagation of elastic waves, paths and travel times for earthquake waves; III. Instruments and instrumental observation of earthquakes; IV. Earthquakes, their terminology, effects, mechanics of occurrence, and the history of seismology; V. Seismic prospecting: the data obtained in the field, the reduction of observations, and special commercial applications.

Geologists, engineers, and other well educated laymen who wish an approximate knowledge of how the seismic methods of prospecting work will find this textbook a readable, detailed, elementary description of those methods plus much readable information on earthquakes. As a textbook, the book will be useful in elementary courses on geophysics primarily for geologists and engineers rather than geophysicists. The book will not appeal to professional seismic exploratory geophysicists. It is the best textbook available on the subject of the seismic methods of prospecting.

The "Practical Geophysics" part of the book is readable but is disappointing in that it does not give the reader even a fairly good picture of that important practical phase of geophysics which is concerned with the effects of earthquakes on man and his activities and with the avoidance or minimization by man of the harmful effects of earthquakes in connection with him and his structures.

[1] The Humble Oil and Refining Company. Manuscript received, September 13, 1938.

RECENT PUBLICATIONS

ALABAMA

"Oligocene Foraminifera from Choctaw Bluff, Alabama," by J. A. Cushman and Winnie McGlamery, *U. S. Geol. Survey Prof. Paper 189-D* (1938), pp. i-ii, 103–19, Pls. 24–28. Supt. Documents, Govt. Printing Office, Washington, D.C. Price, $0.10.

ARGENTINA

*"Bosquejo geológico de la zona que explota Y P F en Tranquitas (Salta)" (Geological Sketch of the Region Explored by the Y P F in Tranquitas, Salta), by Ivo Conci. *Boletin de Informaciones Petroleras* (Buenos Aires), Vol. 15, No. 166 (June, 1938), pp. 67–82; 9 figs.

CALIFORNIA

*"Geology of the Central Santa Monica Mountains, Los Angeles County," by E. K. Soper. *California Jour. Mines Geol.* (San Francisco), Vol. 34, No. 2 (April, 1938), pp. 131–80; 15 figs., 6 tables. Areal geological map in pocket; scale, 1¾ inches: 1 mile.

*"San Andreas Rift, California," by Bailey Willis. *Jour. Geol.* (Chicago), Vol. 46, No. 6 (August–September, 1938), pp. 793–827; 7 figs., 1 pl.

EUROPE

*"Lateral Movements on the Alpine Foreland of Northwestern Europe," by W. A. J. M. van Waterschoot van der Gracht. Reprinted from *Proc. Royal Netherlands Acad. Amsterdam*, Vol. 41, No. 3 (1938). 22 pp., 3 figs., 1 table.

*"A Structural Outline of the Variscan Front and Its Foreland from South-Central England to Eastern Westphalia and Hessen," by W. A. J. M. van Waterschoot van der Gracht. Reprinted from *Compte Rendu du deuxième Congrès pour l'Avancement des Études de Stratigraphie Carbonifère* (Heerlen, 1935, published 1938). 81 pp., 4 figs., tectonic map from the English Midlands to Hessen.

GENERAL

*"Dip-Karten. Beispiele für die Anwendung besonderer Zeichen für Streichen und Fallen" (Dip-Maps. Examples for the Application of Particular Symbols for Strikes and Dips), by Otto Dreher. Reprinted from *Senckenbergiana* (Frankfurt a. M.), Bd. 20, Nr. 3–4 (August, 1938), pp. 221–28; 7 figs.

*"Some Considerations in the Selection and Installation of Gravel Pack for Oil Wells," by C. J. Coberly and E. M. Wagner. *Petrol. Tech.* (Amer. Inst. Min. Met. Eng., New York), Vol. 1, No. 3 (August, 1938), *Tech. Paper 960*. 20 pp., 12 figs., 4 tables.

*"Effect of Temperature on the Gel Strength of Some Gulf Coast Drilling Muds," by B. I. Routh and B. C. Craft. *Ibid., Tech. Paper 961*. 7 pp., 5 figs., 1 table.

*"Significance of the Critical Phenomena in Oil and Gas Production," by D. L. Katz and C. C. Singleterry. *Ibid., Tech Paper 971*. 17 pp., 5 figs., 5 tables.

*"A Method for Determining the Water Content of Sands," by H. G. Botset. *Ibid., Tech. Paper 972*. 7 pp., 1 fig., 1 table.

*"Application of Some Spectroscopic Methods to Problems of Petroleum Geology and Engineering," by Eldon A. Means. *Petrol. Eng.* (Dallas), Vol. 9, No. 13 (September, 1938), pp. 37–40; 4 figs., 2 tables.

The Practical Geology of Oil, by William Wood Porter, II. 145 pp., $5\frac{1}{2}\times8\frac{1}{4}$ inches. Cloth. Gulf Publishing Company (Houston, 1938). Price, $1.50.

*"The Paleozoic Geography and Environment in Northwestern Europe as Compared to North America," by W. A. J. M. van Waterschoot van der Gracht. Reprinted from *Compte Rendu du deuxième Congrès pour l'Avancement des Études de Stratigraphie Carbonifère* (Heerlen, 1935, published, 1938). 73 pp., tectonic map of North America.

GEOPHYSICS

*"Nuevos Puntos de Vista Relativos a la Exploración y Localización de Estructuras Geológicas por el Método Eléctrico Inductivo" (New Points of View Relative to the Exploration and Discovery of Geologic Structures by the Electric Induction Method), by Fritz Ragotzy. *Ingeniería* (Mexico City), Vol. 12, No. 8 (August, 1938), pp. 286–87.

*"Ground Gas Survey Is Promising Tool," by Sylvain J. Pirson. *Oil Weekly* (Houston), Vol. 91, No. 5 (October 10, 1938), pp. 34–44; 4 figs., 2 tables.

GERMANY

*"Die deutschen Salzlagerstätten in den Alpen" (German Salt Deposits in the Alps), by Ernst Fulda. *Kali und Erdöl*, Jahr. 32, Heft 17 (Berlin, September 1, 1938), pp. 182–84; 4 figs. Reprinted from "Steinsalz und Kalisalze" (Rock Salt and Potash Salts), by Ernst Fulda, Volume III, Part 2 of *Deposits of Useful Minerals and Rocks*, edited by Beyschlag, Krusch, Vogt. Ferdinand Enke, Stuttgart (1938). Part 2 of the foregoing article in *Kali und Erdöl*, Jahr. 32, Heft 18 (Berlin, September 15, 1938), pp. 193–96; 7 figs.

ILLINOIS

"Oil and Gas Development Map of Beecher City Area (Tps. 7–9 N., Rs. 3–5 E.)." "Oil and Gas Development Map of Ramsey Area (Tps. 7–9 N., Rs. 1 W., 1–2 E.)." *State Geol. Survey Illinois* (Urbana, 1938). "The maps show towns, main roads (also minor roads in developed areas), section, township and county lines; well locations, rigs, and drilling wells; and oil, gas, dry, and abandoned wells." Blue line prints. Scale, 2 inches: 1 mile. Price, $0.60 each. Order from Enid Townley, map agent, 305 Ceramics Building, Urbana, Illinois.

KENTUCKY

*"The 'McClosky' Oil Horizon in Western Kentucky," by Louise Barton Freeman. *Kentucky Dept. Mines and Minerals Geol. Div.* (Lexington), Ser. 8, Bull. 3 (1938). 22 pp., 2 cross sections.

LOUISIANA AND TEXAS

*"Potentialities of Eocene Series in West Central Louisiana and East Texas," by Paul Thomas. *Oil Weekly* (Houston), Vol. 91, No. 2 (September 19, 1938), pp. 30–34, 38–40; 3 figs.

*"Geophysical Improvements Open Way for Exploring Vast Virgin Area of Upper Coastal Trend," by John D. Todd and Frank C. Roper. *Ibid.*, Vol. 91, No. 4 (October 3, 1938), pp. 25–30; 4 figs.

MEXICO

*"Estratigrafia Preterciaria Preliminar del Estado de Chiapas" (Pre-Tertiary Stratigraphy of the State of Chiapas), by F. K. Müllerried. *Bol. Soc. Geol. Mexicana*, Vol. 9, No. 1 (6a Calle del Ciprés 176, Mexico, D. F., May, 1936), pp. 31–41. Annual subscription to the Bulletin, $4.00; single number, $0.50 (Mexican).

*"Estudio Hidrogeológico de Ucareo, Edo. de Michoacán" (Hydrology of Ucareo, State of Michoacán), by Apolinar Hernández. *Ibid.*, Vol. 10, Nos. 5–6 (May–June, 1937; published, 1938), pp. 147–78; 23 photographs. Includes a petrographic classification and 3 photomicrographs of igneous rocks in the area. Annual subscription (6 numbers), $12.00; single number, $2.00 (Mexican).

*"Bosquejo Geológico de la Región Comprendida Entre los Pueblos Tampamolón, Tanquián y Río Moctezuma" (Geological Sketch of the Region between the Cities of Tampamolón, Tanquián, and the Moctezuma River), by Alberto Terrones Langone. *Ingeniería*, Vol. 12, No. 9 (Mexico City, September 10, 1938), pp. 344–46; 1 map.

MICHIGAN

*"General Features of Michigan Structural Geology," by R. B. Newcombe. *Oil and Gas Jour.* (Tulsa), Vol. 37, No. 18 (September 15, 1938), pp. 24–26; 1 areal geological map, 1 stratigraphic column.

*"Geology of the Clare County Field in Michigan," *ibid.*, Vol. 37, No. 21 (October 6, 1938), pp. 25–27, 34; 2 maps.

NEWFOUNDLAND

*"Geology of the Bay St. George Carboniferous Area," by Albert O. Hayes and Helgi Johnson. *Newfoundland Geol. Survey Bull. 12* (St. John's, 1938). 62 pp., 17 figs., 5 pls. including 3 maps in pocket, 4 tables.

NEW GUINEA

*"Papuan Geology Suggests Good Potentialities," Anon. *World Petrol.* (New York), Vol. 9, No. 9 (September, 1938), p. 45; 2 figs.

NEW MEXICO

"Geologic Structure of Part of Rio Arriba County, New Mexico," by C. H. Dane and R. P. Bryson, *U. S. Geol. Survey* (Washington, D. C., 1938). "A preliminary map showing by contour lines the geologic structure of an area of more than 300 square miles in Rio Arriba County, New Mexico . . . ." Scale, 1 inch: 1 mile. Price, $0.25.

NEW ZEALAND

*"New Zealand Enters Phase of Active Oil Search," Anon. *World Petrol.* (New York), Vol. 9, No. 9 (September, 1938), pp. 38–40; 5 figs.

*"Fossil Flora of Sydney Coalfield, Nova Scotia," by W. A. Bell. *Canada Geol. Survey Mem. 215* (Ottawa, 1938). 334 pp., 107 pls. of fossils, 2 range charts in pocket. Price, $0.75.

PENNSYLVANIA AND NEW YORK

*"Bradford Oil Field, Pennsylvania and New York," by Charles R. Fettke. *Pennsylvania Geol. Survey Fourth Ser. Bull. M 21* (Harrisburg, 1938). 454 pp., 113 figs., 21 pls., 151 tables, 5 maps, including structure, areal, oil and gas maps, in pocket. Approx. 6×9 inches. Cloth. Order from Bureau of Publications, Department of Property and Supplies, Harrisburg, Pennsylvania.

POLAND

**Rocznik Polskiego Towarzystwa Geologicznego* (Annals of the Geological Society of Poland), Vol. 13 (1937) (Krakow, 1938). 286 pp. Illus. 10 articles in Polish and German. "The Foraminiferal Fauna of the Paleogene Flysch of Koniusza near Dobromil," by J. Syniewska, in Polish, summary in French; "Vertical Range of Type Megaspores in the Carboniferous of the Northern Basin," by J. Zerndt, in German, summary in Polish; "Quaternary of the Foreland of Sambor and Dobromil Sheets," by H. Teisseyre, in Polish, summary in French; "A Profile of the Diluvium in Zielonki," by K. Beres, in Polish, summary in German; "The Jurassic at Horodenka and the Division of the Jurassic in Podolie," by K. Głażewski, in Polish, summary in French; "Recent Information about the Interglacials in Winiary near Poznan," by J. Gołąb i J. Urbański, in Polish, summary in German; "The Origin and Chronology of Varved Clays Found in the Interior of an Esker," by R. Błachowski, in Polish, summary in English; "Report and Remarks on the Third International Quaternary Conference in Vienna. Its Excursions," by St. Pawłowski, in Polish, summary in German; "Notes on the Variability of Echinoids," by R. Kongiel, in Polish, summary in French; The Sarmatian of the Vicinity of Szumsk, Mizocz, and Ostrog in Volhynie," by W. Krach, in Polish, summary in French.

ROCKY MOUNTAIN REGION

*"Economics and Geology of the Rocky Mountain Area II," by L. C. Uren. *World Petrol.* (New York), Vol. 9, No. 9 (September, 1938), pp. 50–64; 15 figs. The second installment of an exhaustive study of the oil and gas fields of the Rocky Mountain area.

RUSSIA

*"Some Principal Stages of the History of Great Caucasus during the Tertiary," by V. V. Beloussov. *Problems of Soviet Geology*, Vol. 8, No. 4 (Moscow, April, 1938), pp. 251–69; 4 figs. Summary in English.

*"New Data on the Stratigraphy of the Carboniferous Sediments of the Middle Course of the Ishim River," by S. M. Andronov. *Ibid.*, pp. 321–28. In Russian.

*"Tectonics of Eastern Ciscaucasia," by I. O. Brod. *Soviet Geology*, Vol. 8, No. 7 (Moscow, July, 1938), pp. 3–22; 8 figs. Summary in English.

*"The Problem of Orogenesis and Epeirogenesis Relations," by V. E. Hain. *Ibid.*, pp. 23–44. Summary in English.

TEXAS

"Geology of the Marathon Region, Texas," by P. B. King. *U. S. Geol. Survey Prof. Paper 187* (1938). 148 pp., 24 pls., 33 figs. Supt. Documents, Govt. Printing Office, Washington, D. C. Price, $2.50.

TRINIDAD

*"Trinidad's Reserves Increasing as Result of Intensified Drilling," by M. A. ap Rhys Pryce. *World Petrol.* (New York), Vol. 9, No. 9 (September, 1938), pp. 32–36; 6 figs.

WYOMING

"Preliminary Map Showing Geologic Structure of the Byron-Frannie Area, Wyoming," compiled by D. A. Andrews from field data obtained under his supervision in 1936 and 1937 and from data obtained by C. E. Dobbin and J. C. Miller in 1934 and by W. B. Emery in 1916. *U. S. Geol. Survey* (Washington, D. C., 1938). "This map . . . represents an area of about 170 square miles in which oil and gas have been produced. It includes the Garland, Byron, Little Polecat, Big Polecat, Frannie, and Sage anticlines. It shows State and county boundaries, towns, major drainage lines, roads, railroads, the subdivisions of the land by sections and lots, and the location, status, and names of more than 100 wells that have been drilled in the area. . . . The structure is shown by means of contour lines drawn at intervals of 200 feet." Scale, 1 inch: 1 mile. Price, $0.15.

*"The Structural Geology and Physiography of the Teton Pass Area, Wyoming," by Leland Horberg. *Augustana Library Pub. 16* (Rock Island, Illinois, 1938). 86 pp., 20 figs.

*"The Tensleep Fault, Johnson and Washakie Counties, Wyoming," by Charles W. Wilson, Jr. *Jour. Geol.*, Vol. 46, No. 6 (August–September, 1938), pp. 868–81; 4 figs.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1613-1620

THE ASSOCIATION ROUND TABLE

EDITORIAL

WHERE SHALL OUR YOUNG GRADUATES IN PETROLEUM GEOLOGY ACQUIRE FIELD EXPERIENCE?

FREDERIC H. LAHEE
Dallas, Texas

No business has changed more markedly from year to year, than that which concerns the exploration and exploitation of petroleum. New methods and techniques, and greater depths of drilling, have contributed to an evolution so rapid that there is difficulty, even for those employed in the industry, in keeping abreast of its advancement and requirements. For those who are still outside, this condition may present a real problem.

We have in mind the college course in petroleum geology, and the student who, usually with only the haziest idea of what he wants, elects to become a petroleum geologist. Often he makes his choice because geology, as a science, appeals to him, and he wishes to use his learning in a practical way. Generally he assumes, or he is told, that he is ready for a beginner's job following graduation, and, when he calls for an interview, in nine cases out of ten, he says he wants experience in *field geology;* that he is willing to run "the instrument," or do anything to give him a start in this branch of the science; and that pay is merely of minor importance, as long as he gets enough to live on.

Now, the tragic side of this is that most of the oil companies, certainly in the Gulf Coastal Plain, have *very* little field geology in progress; and where there is field mapping to be done, it is so difficult that it requires men of considerable experience, and not beginners. A large proportion of the work of a geological department in an oil company is subsurface correlation and subsurface mapping, based on the interpretation of data supplied by paleontological study of well samples, by electrical logging, and by geophysical surveys. There is almost no opportunity for a young graduate to obtain experience in field geology, and yet, to build up the background which will be essential for his usefulness as a subsurface geologist, he must somehow get this field experience.

This situation presents a dilemma which should be recognized and carefully studied by geological departments of universities and of oil companies. As time goes on, there will be less and less chance for the young geologist to gain his field experience in the course of his routine duties while employed in an oil company geological department. He must plan to get this training elsewhere, or in some other manner, and before his ambition leads him to apply for a job in subsurface work; for otherwise, if he enters the department as a sample washer (in the paleontological laboratory) or as a sample grabber (gathering, labelling, and shipping samples from a drilling well), he will be distinctly handicapped for later promotion into the subsurface work of that department. He will not be as efficient or as reliable in his attempted interpretations of the subsurface data.

Where is this young man to obtain his field training? Shall it be in ex-

tended courses of study particularly designed to meet his needs in the graduate curricula of the universities? Or shall it be in preliminary courses of intensive study conducted and offered by the oil companies themselves? At the present time state and federal surveys, due to limited funds, probably do not offer opportunities for more than a very few candidates for field training.

We are stating this case briefly, but with the hope that it may awaken interest in the problem of placing the hundreds of aspiring young petroleum geologists coming out of our many universities. We should like to learn the opinions of department heads of oil companies in the several major oil-producing districts of the country. The foregoing comments have resulted from our own experience in the Gulf Coastal district.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Pavand se Ceccatty, Paris, France
P. Charrin, E. G. Leonardon, M. Schlumberger
Charles Albert Durham, Houston, Tex.
L. T. Barrow, L. P. Teas, E. H. Sellards
Alan James Galloway, St. Louis, Mo.
W. van Holst Pellekaan, Robert J. Davis, Floyd A. Nelson
Peter Paul Gregory, Iraan, Tex.
B. E. Thompson, H. M. Bayer, W. E. Hubbard
Roger R. D. Revelle, La Jolla, Calif.
Francis P. Shepard, U. S. Grant, George D. Louderback

FOR ASSOCIATE MEMBERSHIP

Robert Lowell Benish, Corpus Christi, Tex.
E. D. Luman, Sam Aronson, O. E. Walton
Roy Benke, Dallas, Tex.
E. D. Luman, Sam Aronson, Alfred Gray
William Henry Cardwell, Corpus Christi, Tex.
Raymond A. Stehr, E. C. Sargent, Gentry Kidd
Burton Wallace Collins, Madang, New Guinea
Harve Loomis, F. K. G. Mullerried, W. G. Argabrite
Kenneth F. Krammes, Bakersfield, Calif.
Walter A. English, Edward C. Simpson, E. R. Atwill
Roland Olaf Olson, Los Angeles, Calif.
E. K. Soper, U. S. Grant, Frank Rieber
Robert Henry Paschall, South Gate, Calif.
U. S. Grant, E. K. Soper, S. G. Wissler
Phil Porter, Tulsa, Okla.
Charles E. Decker, E. DeGolyer, C. V. Millikan

Robert M. Rigg, Cairo, Egypt
James Z. Zimmerman, J. O. Nomland, T. S. Lovering
John William Ruth, Arcadia, Calif.
William S. W. Kew, Herschel L. Driver, Bruce L. Clark

FOR TRANSFER TO ACTIVE MEMBERSHIP

John M. Campbell, Laredo, Tex.
Olin G. Bell, D. G. Barnett, Arthur H. Petsch
Edward Charles Doell, Taft, Calif.
G. C. Gester, W. F. Barbat, George M. Cunningham
B. L. Graham, Bartlesville, Okla.
William F. Absher, A. K. Wilhelm, Robert L. Kidd
Maurice Kamen Kaye, Caracas, Venezuela, S. A.
Ebert E. Boylan, F. I. Martin, James A. Tong
Willis G. Meyer, Shawnee, Okla.
A. R. Denison, J. W. Kisling, John S. Cruse
A. J. Montgomery, Oklahoma City, Okla.
D. E. Lounsbery, R. A. Conkling, J. K. Knox
Carl James Neer, Corpus Christi, Tex.
Perry Olcott, Wallace C. Thompson, F. W. DeWolf
Lee S. Osborne, Long Beach, Calif.
C. E. Yager, H. J. Steiny, M. G. Edwards
Jack A. Parker, McAllen, Tex.
R. H. Haseltine, C. R. Nichols, R. L. Marston
Willard M. Payne, Shreveport, La.
A. M. Lloyd, W. C. Spooner, Hugh Lee Burchfiel
John Clifton Poole, Corpus Christi, Tex.
J. David Hedley, Herschel H. Cooper, Fred P. Shayes
Edwin M. Reed, Houston, Tex.
W. C. Bean, F. B. Plummer, George S. Rollin

(Continued on page 1627)

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, WASHINGTON, D. C., SEPTEMBER 4–15, 1939

Information has been received that the President of the United States has invited the International Union of Geodesy and Geophysics to hold its seventh general assembly in the United States in 1939. The invitations have been extended on behalf of the President by the Department of State through its diplomatic missions to the governments to which these missions are accredited.

It is planned to hold this seventh triennial assembly of the Union in Washington, September 4–15, 1939, according to a statement made by John A. Fleming, director of the Carnegie Institution's Department of Terrestrial Magnetism, who is general secretary of the American Geophysical Union. The American Geophysical Union is the American Section of the International Union of Geodesy and Geophysics, and its executive committee is the committee on geophysics of the National Research Council. The Council is collaborating with the American Geophysical Union as host to the assembly. The last general assembly of the International Union was held at Edinburgh, Scotland, in September, 1936.

The 35 nations at present adhering to the International Union are: Argentina, Belgium, Brazil, Bulgaria, Canada, Colombia, Chile, Czechoslovakia, Denmark, Egypt, Finland, France, Germany, Great Britain, Greece, Holland, Hungary, Indo-China, Italy, Japan, Morocco, Mexico, New Zealand, Norway, Peru, Poland, Portugal, Rumania, Siam, Spain, Sweden, Switzerland, Union of Soviet Socialist Republics, United States, and Yugoslavia.

A statement by N. H. Heck, chairman of the American Geophysical Union, about the organization and function of the Union was printed in *Science*, Vol. 87, No. 2260 (Washington, D. C., April 22, 1938), pp. 353–57.

Further information may be obtained from Harlan T. Stetson, chairman of the committee on publicity, Massachusetts Institute of Technology, Cambridge, Massachusetts.

PROPOSED NEW DEFINITION OF LINEAR UNITS[1]

R. M. WILSON[2]
Washington, D.C.

At the annual meeting in Washington on April 27, 1938, of the Section of Geodesy, American Geophysical Union, a motion presented by Professor Kissam of Princeton University was adopted, providing for a committee to study the effect of the new definitions of the linear units now in common use in the United States as proposed in a bill which at that time was before the Congress of the United States (H.R. 8974).

A committee was appointed consisting of L. V. Judson of the National Bureau of Standards, Hugh C. Mitchell of the U.S. Coast and Geodetic Survey, and R. M. Wilson of the U.S. Geological Survey. That committee is now seeking the assistance of scientific organizations throughout the country by means of a questionnaire which directs attention to the proposed shortening of the inch. Information is being sought as to the possible effects of the proposed change on geodetic and geophysical work, scientific investigations and engineering projects on which those addressed may be engaged.

Should any readers of the *Bulletin* of the American Association of Petroleum Geologists be interested in this matter, and desire to contribute constructive comments thereon, the committee will appreciate very much hearing from them. Please address the chairman, R. M. Wilson, U.S. Geological Survey, Washington, D.C.

[1] Letter dated, September 30, 1938.

[2] Chairman, special committee, American Geophysical Union.

ORIGIN OF ASSOCIATION COMMITTEES

At the annual meeting in New Orleans in March, 1938, the following motion was passed by the business committee.

> Resolved, that it be the sentiment of this meeting that the incoming president, with the assistance of the incoming executive committee, make a complete study and review of all Association committees, their functions and personnel, and that a complete report of findings with recommendations be presented at the business meeting next year.

Accordingly, president Barton has appointed a committee to study Association committees: R. S. McFarland, chairman, J. G. Bartram, F. R. Clark, W. B. Emery, F. H. Lahee, A. I. Levorsen, W. G. Wissler.

In order that all of the members may have an opportunity to know the origin and purpose of the present committees, the following analysis is presented.

1. EXECUTIVE. Established in 1917 by the Constitution of the Southwestern Association of Petroleum Geologists, Art. IV, Sec. 4.

Purpose when established: "The executive committee shall consider all nominations for membership and pass on the qualifications of the applicant, shall have control of the Association's work and property, shall determine the manner of publication and pass on all materials presented for publication, and may call special meetings when and where thought advisable and arrange for the affairs of the same."

Present committee of 5 elected, March 16, 1938.

2. BUSINESS. A "General Committee" was functioning as early as 1921.

At the annual meeting of March 25, 1927, the following recommendation of the "Business Committee," to amend the by-laws, was adopted: "Add a new section to provide for a General Business Committee to be elected by members of various districts in local meetings (districts to be decided upon by the Executive Committee); number of delegates elected from each district to be determined by number of full members residing in said district; term of office to extend over three-year period, one-third of the members retiring each year; in case districts fail to elect representatives, the same to be elected by the Executive Committee thirty days before the annual meeting. This General Business Committee to act as a council for the Association and as an Advisory Board to the Executive Committee."

On March 23, 1929, the annual meeting of the Association amended the by-laws so that Section 6 reads as follows.

"Sec. 6. There shall be a business committee to act as a council and advisory board to the executive committee and the Association. This committee shall be made up of the executive committee, not more than five members at large appointed by the president, two members elected by and from each technical section, and the district representatives. . . . . " With slight changes, this is Art. VI of the present by-laws.

Present committee of 34 elected within past 2 years. District representative term of office, 2 years.

3. RESEARCH. On March 30, 1923, the executive committee created a "Committee on Research," with W. E. Wrather as chairman.

In 1929, Donald C. Barton stated, "The purpose of the research committee is the advancement of research within the field of petroleum geology."

Present committee of 18 appointed by the president within the past 3 years. Term of office, 3 years. Two of the present members were first appointed in 1929.

4. REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY, NATIONAL RESEARCH COUNCIL. K. C. Heald represented the Association in 1923.

Present representative appointed by the president within past 3 years. Term of office, 3 years.

5. GEOLOGIC NAMES AND CORRELATIONS. On March 26, 1932, the Association adopted the following resolution: "That the committee on geologic names

and correlations appointed by president L. P. Garrett be made a permanent committee subject only to changes caused by resignation or other sufficient reason."

Purpose.—To lend assistance to authors on problems of stratigraphic nomenclature.

A few of the present 17 members were appointed in 1932.

6. TRUSTEES OF REVOLVING PUBLICATION FUND. On March 21, 1931, the Association adopted the following resolution.

"Trusteeships.—In conformity with the action of the executive committee at Tulsa, Oklahoma, May 23, 1930, it was decided that the executive committee instruct the president to appoint trusteeships for the research and revolving publication funds."

"Each trusteeship shall consist of three members, each of whom will be appointed to serve for 3 years, but in rotation, one member being appointed each year. To accomplish this method of tenure, one of the first appointees shall serve for 1 year only; and another for 2 years only. Except for these two, all appointments shall be for 3-year terms. Selection of members of these trusteeships shall be made by the executive committee."

Purpose.—Executive committee, May 23, 1930, recommended "That their approval (the trustees) be secured before using the fund for any publication project. The recommendations and approval of the executive committee will be necessary in addition to the trustees' recommendation."

One of the present trustees was appointed in 1934.

7. TRUSTEES OF RESEARCH FUND. (See statement under Revolving Publication Fund.)

Trustees' advice may be secured before using fund.

One of the present trustees was appointed in 1931.

8. FINANCE. On March 26, 1932, the Association adopted the following resolution.

"Resolved that the Business Committee approves of the resolution of the Executive Committee to recommend to the Association that a committee on finance be appointed, said finance committee to be composed of three men whose terms of appointment shall run from one, two, and three years respectively; that only one additional appointment for a period of three years be made at the expiration of the term of service: the duties of the Finance Committee being to study investments of the Association and advise the Executive Committee regarding the sale of investments and the re-investing of Association funds that may be available for that purpose."

One of the present members was appointed in 1932.

9. APPLICATIONS OF GEOLOGY. On March 26, 1932, the Association adopted the following resolution.

"Resolved that a Committee on Public Relations be appointed by the president; the object of this committee being to advise and promote ways and means for informing the general public in regard to the natural occurrence of oil and gas underground, the methods of searching for these substances and the methods of exploiting them."

On March 22, 1933, the Association adopted the following resolution.

"Whereas, the functions of the committee on public relations are educational; and

Whereas, the name 'public relations' may create a false impression of the aims and interests of this committee; there be it

Resolved, that the name of this committee be changed to 'Committee on Applications of Geology,' and be it further

Resolved, that this committee, appointed by President F. H. Lahee, be made a permanent committee of the Association, subject to changes caused only by resignations or other sufficient reason."

A few of the present 13 members were appointed in 1932.

10. PUBLICATION. In 1937 F. H. Lahee was appointed chairman of a committee for publication, as a result of suggestions offered at the annual meeting of 1937. On March 14, 1938, the executive committee adopted a resolution making the committee permanent.

Purpose.—To get more manuscripts for the *Bulletin*.

ASSOCIATION COMMITTEES

EXECUTIVE COMMITTEE

Donald C. Barton, *chairman*, Houston, Texas
H. B. Fuqua, Fort Worth, Texas
Ira H. Cram, *secretary*, Tulsa, Oklahoma
Harold W. Hoots, Los Angeles, California
W. A. Ver Wiebe, Wichita, Kansas

BUSINESS COMMITTEE

Carl C. Anderson (1940)
Arthur A. Baker (1940)
Donald C. Barton (1940)
William A. Baker (1939)
Orval L. Brace (1939)
Cary P. Butcher (1939)
Frederic A. Bush (1939)
Harold S. Cave (1939)
Ira H. Cram (1939)
A. F. Crider (1939)
A. Arthur Curtice (1939)
H. B. Fuqua (1939)
Benjamin F. Hake (1939)
V. G. Hill (1939)
Harold W. Hoots (1939)
H. V. Howe (1939)
J. Harlan Johnson (1939)
Edward A. Koester (1939)
P. W. McFarland (1940)
David Perry Olcott (1939)
Virgil Pettigrew (1940)
Paul H. Price (1939)
R. B. Rutledge (1939)
R. F. Schoolfield (1939)
E. H. Sellards (1939)
Fred P. Shayes (1939)
S. E. Slipper (1939)
Homer J. Steiny (1939)
W. T. Thom, Jr. (1939)
Wallace C. Thompson (1940)
James A. Tong (1939)
Walter A. Ver Wiebe (1939)
Andrew C. Wright (1939)
Charles E. Yager (1939)

RESEARCH COMMITTEE

A. I. Levorsen (1941), *chairman*, 221 Woodward Boulevard, Tulsa, Oklahoma
Harold W. Hoots (1939), *vice-chairman*, Richfield Oil Corporation, Los Angeles, California
M. G. Cheney (1941), *vice-chairman*, Coleman, Texas

Donald C. Barton (1939)
Glenn H. Bowes (1939)
W. L. Goldston (1939)
W. C. Spooner (1939)
Parker D Trask (1939)
Maurice M. Albertson (1940)
Rollin Eckis (1940)
William E. Hubbard (1940)
John C. Karcher (1940)
Norman L. Thomas (1940)
N. W. Bass (1941)
E. Wayne Galliher (1941)
H. Hlauschek (1941)
Walter Kauenhowen (1941)
Ben H. Parker (1941)
Wendell P. Rand (1941)

REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY NATIONAL RESEARCH COUNCIL

Frederic H. Lahee (1940)

GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

John G. Bartram, *chairman*, Stanolind Oil and Gas Company, Casper, Wyoming
Glenn S. Dille, *vice-chairman*, 808 Atlas Building, Tulsa, Oklahoma

J. E. Adams
M. G. Cheney
Alexander Deussen
Robert H. Dott
Anthony Folger
B. F. Hake
G. D. Hanna
M. C. Israelsky
R. M. Kleinpell
C. L. Moody
R. C. Moore
Ed. W. Owen
Paul H. Price
R. E. Sherrill
N. L. Thomas

TRUSTEES OF REVOLVING PUBLICATION FUND

J. V. Howell (1939)
Ralph D. Reed (1940)
Ben F. Hake (1941)

TRUSTEES OF RESEARCH FUND

Alex W. McCoy (1939)
Robert J. Riggs (1940)
A. A. Baker (1941)

FINANCE COMMITTEE

W. B. Heroy (1939)
E. DeGolyer (1940)
Wallace E. Pratt (1941)

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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1621-1622

Memorial

CLYDE M. BECKER
(1882–1938)

On July 19, 1938, Clyde M. Becker died at his home in Chickasha, Oklahoma, from a cerebral hemorrhage. Following an attack of influenza a year and a half ago, he developed high blood pressure which resulted in a heart attack on December 16, 1937. He is survived by his widow, Bessie A. Becker, and six sons, Fred W. of Kingman, Arizona, Robert, Theodore, Donald, Phillip, and Clyde, Jr., all of Chickasha.

Clyde Becker was born in Arlington, Iowa, May 23, 1882. He was of German ancestry. He attended Epworth University at Oklahoma City from 1908 to 1911, and received the bachelor of science degree from Oklahoma Baptist University in 1912. Soon after graduation he secured a job as mine superintendent in Colorado with the Seabird Gold Mining Company. From that time until 1918 he was connected with the Republic Mining Company at Hanover, New Mexico, the Empire Zinc Company also of Hanover, and spent some time as an independent operator.

At the advent of the World War, he served as Y.M.C.A. director, later becoming first lieutenant with the Army Engineers. At the close of the war, he spent a year as camp general secretary for the Army Y.M.C.A. at Fort Sill.

In 1919 Mr. Becker became associated with the oil industry, doing geological work for the H. H. Simmons Company in southeastern Kansas. In 1921 the Becker-Reed Oil and Gas Company was formed with Becker as president and succeeded in opening several small fields in that area. The following year they transferred their activities to southwestern Oklahoma and were active there until 1930. Becker is credited with the discovery of the Carter-Knox field of southwestern Oklahoma.

In 1932 he became associated for a short time with the Oklahoma State Conservation Department as deputy proration umpire, later resigning his job to become active again in the mining industry, which resulted in the opening of the Portland Gold Mine at Kingman, Arizona. This mine has developed into one of the best producers in the state. Also during this time he served as consulting geologist for Mandeville and Thompson, later becoming associated with Ray Stevens in extending the Cement oil field in Caddo County, Oklahoma. His faith in the future of southwest Oklahoma is best known by those who were associated with him.

Becker's activities as a consulting geologist were not confined to the United States. He was sent as technical adviser to Mexico and Canada by several companies.

Although his profession kept him away from home a great deal, he still found time to take an active part in the social and civic life of his community. He served on the local board of education, and was an active member of the Methodist Church where his influence on the young people will be felt for many years. Becker became a member of The American Association of Petroleum Geologists in 1921. He was also a member of The American Institute of Mining and Metallurgical Engineers. His likeable personality, his

technical knowledge, and unswerving honesty made and kept for him countless friends throughout the southwest. His sense of humor was adequate to any situation. This is best exemplified by his poems and ballads dealing with geology and the petroleum industry.

No tribute to Clyde Becker would be complete which did not mention his keen interest in the younger members of the geological profession many of whom received their first experience and counsel under his guidance. He was one of the pioneers of the industry and our sense of loss at his untimely passing can not be fully expressed in words.

L. J. Fulton

Olney, Illinois
September 20, 1938

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 22, NO. 11 (NOVEMBER, 1938), PP. 1623-1628

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

W. A. Thomas has resigned his position as chief geologist for McClanahan Oil Company to do consulting work in geology and petroleum engineering with offices in Mount Pleasant, Michigan.

E. H. Finch, San Antonio, Texas, recently returned from England on the Queen Mary after several months in southwest Africa.

C. R. McKnight, Arkansas Fuel Oil Company, Shreveport, Louisiana, has charge of the night courses in geology at Centenary College.

J. Brian Eby, Houston, spoke before the natural gas session of the American Gas Association at the annual convention, October 10–13, at Atlantic City, New Jersey. His subject was "Geophysical Methods of Exploration."

William W. Keeler, formerly with the Minnehoma Oil and Gas Company at Tulsa, is now with the Skelly Oil Company at Mattoon, Illinois.

Robert H. Smith, formerly with the Shell Oil Company at Houston, is now at Mattoon, Illinois.

J. W. Stovall, University of Oklahoma, spoke before the Tulsa Geological Society, October 3, on "Some Facts Concerning the Origin of the Dakota Sandstone."

George Y. McCoy has resigned his position as geological engineer in the valuation section of the Skelly Oil Company at Tulsa, to assume an instructorship in the department of petroleum engineering at the University of Texas at Austin.

W. R. Longmire, Gulf Oil Corporation, has been transferred from Tulsa to Indianapolis, Indiana, where he is assistant to B. F. Hake. He has been replaced at Tulsa by E. W. Scudder, formerly with the Gulf Oil Corporation at Denver.

J. A. Price, W. C. McBride, Inc., has been transferred from Tulsa to Centralia, Illinois, where he is division geologist.

Dan D. Heninger, formerly of San Antonio, Texas, may now be addressed at 726 Hamilton Building, Wichita Falls, Texas. He is with the Ohio Oil Company.

Clyde O. Hudgens, Gulf Refining Company, has been transferred from Roswell, New Mexico, to Indianapolis, Indiana.

D. A. Holm is petroleum geologist with the State Land Department of Arizona at Phoenix, engaged in making a classification of State lands with regard to oil possibilities.

C. E. HAMILTON, of Harper and Turner, 504 Hightower Building, Oklahoma City, has succeeded R. B. CURRY as secretary-treasurer of the Oklahoma City Geological Society. Technical program meetings are held on the second Monday of each month, at 8:00 P.M., on the ninth floor of the Commerce Exchange Building.

R. B. CURRY, of the Carter Oil Company, has been transferred from Oklahoma City to Edinburg, Texas.

The Illinois Geological Society, at Centralia, August 22, elected the following officers: president, LYNN K. LEE, Pure Oil Company; vice-president, VERNER JONES, Magnolia Petroleum Company; secretary-treasurer, J. R. McGEHEE, Box 476, Shell Petroleum Corporation. DONALD C. BARTON, president of the Association, addressed the meeting.

WALTER H. HEGWEIN has changed his address from Av. Juan Acuna 245, Lomas de Chapultepec, Mexico, D. F., to Hoeheweg 36, Liebefeld, Berne, Switzerland.

W. G. MEYER has resigned his position as geologist for the Amerada Petroleum Corporation at Shawnee, Oklahoma, to become associated with E. DEGOLYER at Dallas, Texas.

D. PERRY OLCOTT, Humble Oil and Refining Company, has been elected president of the Houston Geological Society. R. A. WEINGARTNER, Stanolind Oil and Gas Company, is vice-president, and CARLETON D. SPEED, Speed Oil Company, is secretary-treasurer.

W. VAN HOLST PELLEKAAN has retired from the Shell Petroleum Corporation, St. Louis, Missouri, after 25 years of service.

CHESTER C. CLARK, Union Producing Company, was elected president of the Shreveport Geological Society at a meeting on October 7. LESLIE S. HARLOWE, Grogan Oil Company, was elected vice-president, and E. FLOYD MILLER, Oliphant Oil Corporation, 927 Commercial Bank Building, was elected secretary-treasurer.

E. G. DAHLGREN, director of the oil and gas conservation division of the Kansas Corporation Commission, will name the new pools in Kansas according to the recommendations of the oil-field nomenclature committee of the Kansas Geological Society, the chairman of which is L. W. KESLER.

HUGH L. BURCHFIEL, The California Company, has been transferred from Shreveport, Louisiana, to Houston, Texas.

A. E. FATH, Socony Vacuum Oil Company, formerly at The Hague, Netherlands, may now be addressed at 62 Sharia Ibrahim Pasha, Cairo, Egypt.

E. A. L. GEVAERTS has accepted a position as field geologist with the Burmah Oil Corporation, Rangoon.

MICHAEL ALLON, formerly with the Mene Grande Oil Company at Ciudad Bolivar, Venezuela, may now be addressed at 1031 Farragut Street, Pittsburgh, Pennsylvania.

MILTON W. LEWIS, formerly with The Rieber Laboratory in Los Angeles, is now associated with WALKER S. CLUTE as engineer and petroleum geologist. He may be addressed at 201 Signal Oil Building, Los Angeles, California.

F. E. POULSEN, Pure Oil Company, discussed the possibilities of oil production in Haiti at a recent luncheon meeting of the Fort Worth Geological Society.

KURT DE COUSSER, Socony Vacuum Oil Company, Lansing, Michigan, has been placed in charge of both the geological and production divisions of the company in Michigan.

F. R. S. HENSON has returned to Kirkuk, Iraq, after 5 months vacation in England.

EVERETT S. SHAW, formerly with the Midwest Refining Company of Denver, Colorado, will sail from New York on December 1, for Buenos Aires, Argentina, where he will be associated with the Yacimientos Petroliferos Fiscales as assistant to GLEN M. RUBY.

CARL L. BRYAN, formerly of Pittsburgh, Pennsylvania, may now be addressed at Storegade 31, Haderslev, Denmark.

J. HARLAN JOHNSON spoke before the Rocky Mountain Association of Petroleum Geologists, at Denver, Colorado, October 17, 1938, on "A Visit to France during the Past Summer."

LEAVITT CORNING, JR., San Antonio, spoke before the Houston Geological Society, October 13, on "Geology of Goliad and DeWitt Counties, Texas."

E. E. ROSAIRE, Houston, Texas, spoke before the Tulsa Geological Society, October 17, on "The Interpretation of Soil Analyses." He recently spoke before a special meeting of the Kansas Geological Society, Wichita, on "The Relationship of Future Oil Discoveries to Stratigraphic Prospects."

GEORGE A. SEVERSON, The Texas Company, has changed his address from New York to Caixa Postal No. 520, Rio de Janeiro, Brazil.

FRANK A. OYSTER, whose address was formerly 815 Mims Building, Abilene, Texas, may now be addressed at Box 195, Mattoon, Illinois.

CECIL V. HAGEN, Superior Oil Company, Houston, Texas, spoke before the Houston Geological Society, October 27, on "The Geology of the West Flank of the Jennings Oil Field, Acadia Parish, Louisiana."

CHARLES P. MCGAHA, Fain-McGaha Oil Corporation, Wichita Falls, Texas, has been re-elected president of the Texas Division of the Mid-Continent Oil and Gas Association.

H. G. WALTER, The Texas Company, Amarillo, Texas, discussed the "Geology of Southeast New Mexico" at a meeting of the Panhandle Geological Society, November 3.

H. S. CAVE, Roswell, New Mexico, J. HARLAN JOHNSON, Colorado School of Mines, Golden, Colorado, and DON B. GOULD, Colorado College, led the members of the Panhandle Geological Society on a field trip in northern New Mexico, November 5–6.

CHARLES W. FLAGLER, formerly with the Mene Grande Oil Company, in South America, has been appointed London resident geologist for the Gulf Exploration Company of Great Britain. He succeeds PARKER A. ROBERTSON.

HOWARD S. BRYANT, of the Skelly Oil Company, Wichita, W. L. STRYKER, consultant of Fredonia, and MARVIN LEE, consulting geologist of Wichita, are members of a Mineral Industries Council which acts as an advisory board to the "Little Legislature" of Kansas.

The Kansas Geological Society announces that due to the demand for logs of wells in the Forest City basin, it is assembling and will sell the logs of wells drilled in Missouri, Iowa, Nebraska, as well as northeastern Kansas. Copies of a base map of the Forest City basin on a scale of 1:500,000 are available. These may be secured from the Kansas Well Log Bureau, 412 Union National Bank Building, Wichita, Kansas.

HOWARD S. BRYANT is giving a series of lectures at the opportunity school in Wichita, Kansas, on "Geology of Kansas Oil and Gas Fields."

N. H. DARTON, United States Geological Survey, retired, was the guest of honor of the Twelfth Annual Field Conference of the Kansas Geological Society.

The Sixth Annual Tri-State Field Conference conducted in southwestern Iowa, October 29 and 30, under the leadership of L. M. CLINE, of Iowa State College, Ames, Iowa, attracted about twenty-five oil geologists from Wichita, Kansas, and Bartlesville and Tulsa, Oklahoma.

FORREST E. WIMBISH, Magnolia Petroleum Company, has been temporarily transferred to Mattoon, Illinois.

Members of the Kansas Geological Society held their November meeting at Lawrence, Kansas, Saturday morning, November 5, as guests of the members of the Geological Faculty of the University of Kansas, and of the State Geological Survey.

ROBERT S. PALMER spoke before the Rocky Mountain Association of Petroleum Geologists at Denver, Colorado, November 7, on "Colorado Metal Mining Fund."

The newly elected officers for 1938–39 of the East Texas Geological Society, Tyler, are as follows: president, A. C. WRIGHT, Shell Petroleum Corporation; vice-president, E. M. RICE, Pure Oil Company; secretary-treasurer, F. J. SCHEMPP, Stanolind Oil and Gas Company.

ROLLIN T. CHAMBERLIN, of Chicago University, spoke before the Tulsa Geological Society, November 7, on "Structures of the Middle Rocky Mountains."

The officers of the Michigan Geological Society are: president, BEN F. HAKE, Gulf Refining Company; vice-president, A. E. NEWMAN, Department of Conservation; secretary-treasurer, R. W. BECK, the Carter Oil Company, Saginaw; business manager, S. G. BERQUIST, Michigan State College.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

(Continued from page 1615)

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Hugh Tim Richardson, Houston, Tex.
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985 Gilbert Street, Boulder
2nd Vice-President - - - David B. Miller
1336 Gaylord Street
Secretary-Treasurer - - - - - - - Ninetta Davis
224 U. S. Customs Building

Dinner meetings, first and third Mondays of each month, 6:15 P.M., Auditorium Hotel.

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517 North Chautauqua
Member of Board - - - - - George H. Norton
Atlantic Refining Company

Regular Meetings: 7:30 P.M., Allis Hotel, first Tuesday of each month. Visitors cordially welcomed.
The Society sponsors the Kansas Well Log Bureau which is located at 412 Union National Bank Building.

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SHREVEPORT, LOUISIANA

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Oliphant Oil Company, 927 Commercial Bldg.

Meets the first Friday of every month, 7:30 P.M., Civil Courts Room, Caddo Parish Court House. Special dinner meetings by announcement.

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Treasurer - - - - - - - Baker Hoskins
Shell Petroleum Corporation

Meetings: First Monday at noon (12:00) and third Monday at 7:00 P.M. at Majestic Hotel. Visiting geologists are welcome to all meetings.

MICHIGAN

MICHIGAN GEOLOGICAL SOCIETY

President - - - - - - - Ben F. Hake
Gulf Refining Company

Vice-President - - - - - A. E. Newman
Department of Conservation

Secretary-Treasurer - - - - - R. W. Beck
The Carter Oil Company
240 Goff Building, Saginaw

Business Manager - - - - - S. G. Berquist
Michigan State College

Meetings: Monthly dinner meetings rotating between Saginaw, Mt. Pleasant, and Lansing. Informal dress.

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Chairman Program Committee - - Don L. Hyatt
Carter Oil Company, Dillard, Oklahoma

Meetings: First Tuesday of each month, from October to May, inclusive, at 7:30 P.M., Dornick Hills Country Club.

OKLAHOMA CITY GEOLOGICAL SOCIETY
OKLAHOMA CITY, OKLAHOMA

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Coline Oil Company

Vice-President - - - - Dan O. Howard
Oklahoma Corporation Commission

Secretary-Treasurer - - - - - C. E. Hamilton
Harper and Turner, 504 Hightower Building

Meetings, Ninth Floor, Commerce Exchange Building: Technical Program, second Monday, each month, 8:00 P.M.; Luncheons, every Monday, 12:15 P.M.

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Amerada Petroleum Corporation

Meets the fourth Monday of each month at 8:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.

THE STRATIGRAPHIC SOCIETY OF TULSA
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Tide Water Associated Oil Company

Meetings: Second and fourth Wednesdays, each month, from October to May, inclusive, at 8:00 P.M.

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Shell Petroleum Corporation

Secretary-Treasurer - - - - - - L. A. Johnston
Sunray Oil Company

Editor - - - - - - - - R. V. Hollingsworth
Shell Petroleum Corporation

Meetings: First and third Mondays, each month, from October to May, inclusive, at 8:00 P.M., fourth floor, Tulsa Building. Luncheons: Every Thursday, fourth floor, Tulsa Building.

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932 Liberty Building

Vice-President - - - - - - R. E. Rettger
Sun Oil Company

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Magnolia Petroleum Company

Meetings: Regular luncheons, first Monday of each month, 12:15 noon, Petroleum Club. Special night meetings by announcement.

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TYLER, TEXAS

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Shell Petroleum Corporation

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Pure Oil Company

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Stanolind Oil and Gas Company

Meetings: Monthly and by call.
Luncheons: Every Friday, Blue Room, Blackstone Hotel.

TEXAS

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Meetings: Luncheon at noon, Worth Hotel, every Monday. Special meetings called by executive committee. Visiting geologists are welcome to all meetings.

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Regular meetings, every Thursday at noon (12:15) at the Houston Club. Frequent special meetings called by the executive committee. For any particulars pertaining to meetings call the secretary.

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814 Hamilton Building

Luncheons and evening programs will be announced.

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Executive Committee - - - - - D. G. Barnett

Meetings: Third Friday of each month at 8 P.M. at the Petroleum Club. Luncheons every Monday noon at Petroleum Club, Alamo National Building, San Antonio, and at Plaza Hotel, Corpus Christi.

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Secretary-Treasurer - - - - - - - W. C. Fritz
Skelly Oil Company, Midland

Meetings will be announced

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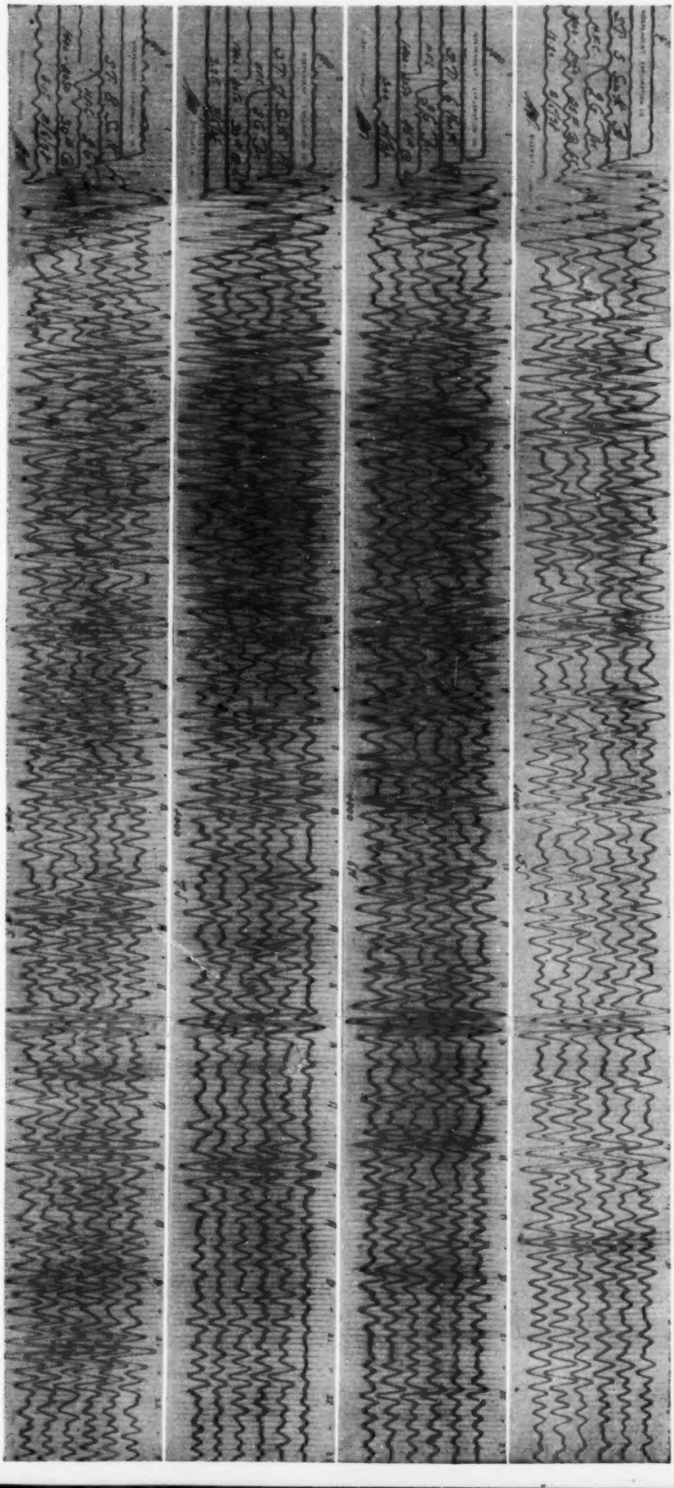

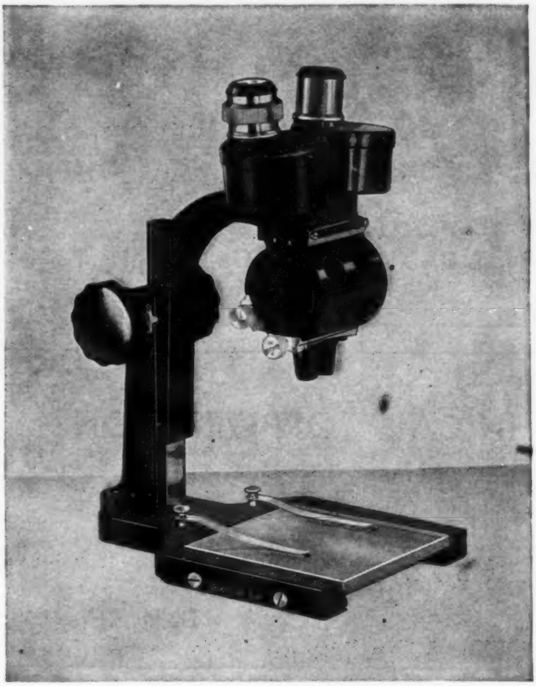

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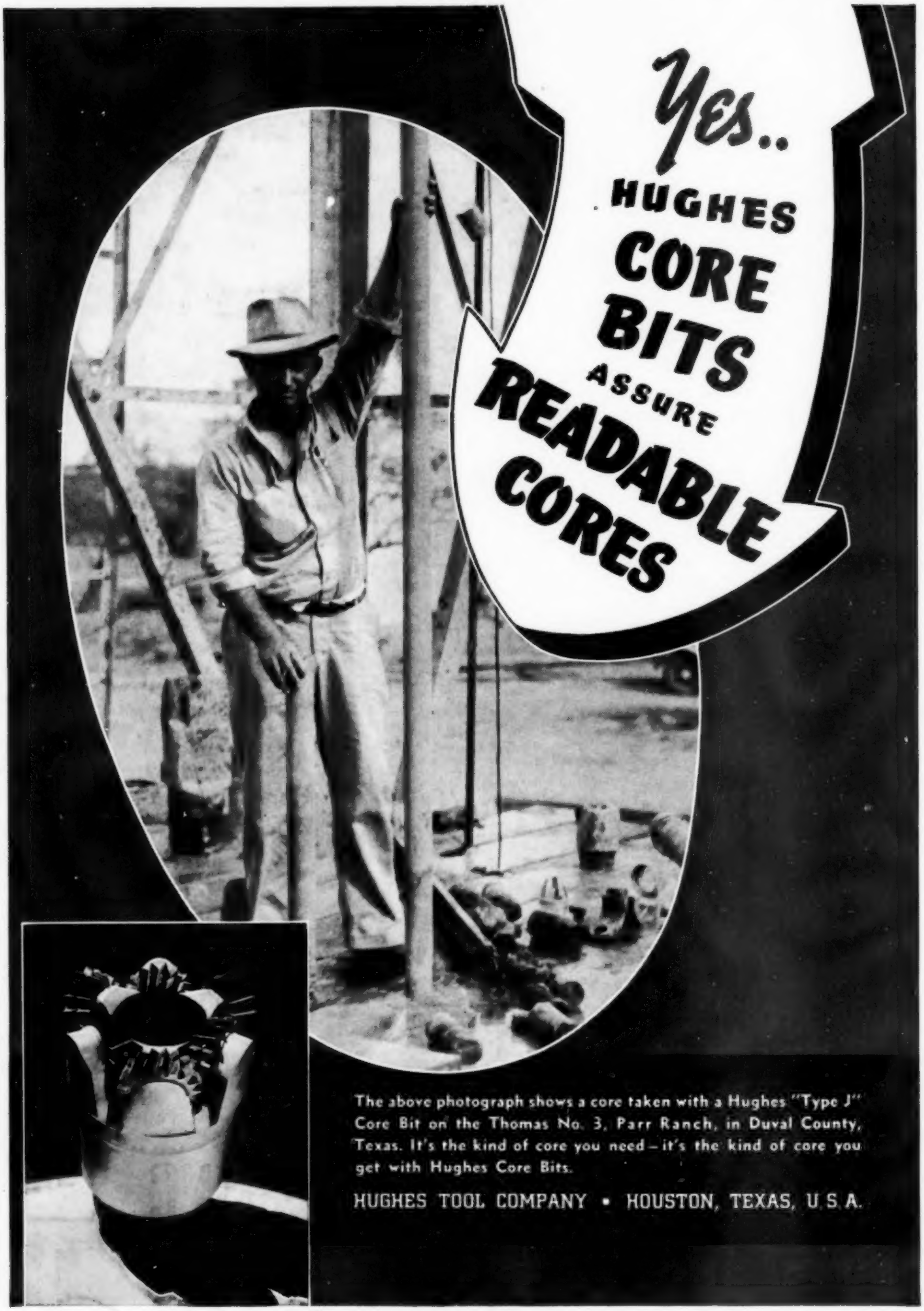
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